

THE (MOST USEFUL) TECHNOLOGY ISSUE (EVER)

Popular Mechanics

HOW YOUR WORLD WORKS

How to
Damp-Proof
Your
Basement
p. 90 ▶



America's Magazine
Since 1902

THE ALL-TECH GIFT GUIDE

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BEST TOYS OF THE YEAR

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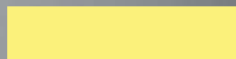
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• What's Coming in 2015
(Good Things. A Lot of Good Things)

Real Innovation
vs.
Fake Innovation
A MANIFESTO BY
Steve Wozniak



IS THIS
STUPID?
OR
AMAZING?
THE WORLD'S FIRST
FAMILY ROBOT :)

◀ Its name is Jibo.
Read about it on p. 100.

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THE TECHNOLOGY ISSUE

Innovation, Defined

By **Steve Wozniak**

THE PYRAMIDS WERE HARD TO PUT TOGETHER, but being hard to do doesn't make something innovative. Technology has to move mankind forward, and the pyramids were not much more than a kid trying to build the biggest sand castle at the beach. It's the same with the moon landing: Maybe it'll get us closer to colonizing other planets, or maybe we did it just because it was there. Right now it's hard to say. The loom, though. There's an example of a piece of technology. It made a person 100 times more efficient and was a step toward the industrial age. And when the printing press came along, it let us spread an idea further than ever before—much more than was possible by a person talking to another person over dinner.

That's where the distinction comes in. Technology is really just an amplifier of our abilities. It builds on itself, letting us do more—and do it faster. If you're a great scientist, like Newton or Einstein, you unravel some mysteries and pass that information on to others.

There's always a starting point, like a seed. And the one seed of technology with the most things emerging from it is obvious: the transistor. The transistor led to the microchip, and that led to the incredible amount of intelligence we have in the palm of our hand today. Every bit of technology we have in our computers, smartphones, and tablets, or in the huge computers and hard disks in the data centers, that's all thanks to the transistor. It's the one invention that hasn't really been replaced.

Don't assume it's all a matter of perspective. The computer isn't this generation's abacus or even this generation's typewriter. The difference is that the

typewriter—and the Internet currently threatens the printing press with a similar fate—is gone. Completely obsolete. Even when the typewriter was the best thing out there, barely any kids learned how to type. Maybe a few in a summer class. But now every kid has to learn how to use a computer keyboard. You can't function without it.

Or compare the iPhone and the television. The TV was invented just before I was born, and the reaction was astounding: *What*

would we ever have done without it? Well, you know what? We had movies before TV. Before that we had plays, all the way back to ancient Greece. There was always some form of entertainment, so how can we say one is better or different than another? But the iPhone isn't just another form of entertainment. It changed productivity. It changed our habits. And what's running the iPhone? A transistor.



The transistor brought us to a unique point, shifting our technological progress from hardware to software. When I was young, a vacuum cleaner was basically the same as it is 40 years later. Maybe a different company name is on it, and it's made with plastic instead of metal, but vacuums haven't really changed a lot. Back then you designed a better rake or a better door handle, and you sold it. Those were hardware changes. They were slow to happen. But software lets us move at a faster pace than ever. You can add all the changes you want and push it out to millions of people almost instantly and virtually for free.

Take this example: I designed a video arcade game for Atari called Breakout—a bunch of bricks at the top of the screen and a paddle that moved along the bottom, bouncing a ball up to destroy the bricks. I wrote that game in half an hour. I could easily change the colors, change the speed of the ball, change where the score appeared on the screen. If I had been working with hardware, it would have taken me 10 years to do what I did in 30 minutes. That's 175,000 times faster. That's the advantage software gives us over hardware. Things are changing more quickly today than ever before. Past eras simply can't compete.

For proof, just look at the Internet. Nobody could have imagined typing something and everyone in the world being able to see it instantly. The Internet really is the biggest innovation in history. It's more important than the computer, even more important than the transistor. The Internet came and everything became for everyone. We were set free. Let's see the pyramids do that.

Technology is really just an amplifier of our abilities. It lets us do more—and faster.



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DECEMBER / JANUARY
2015



**Popular
Mechanics**

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THE TECHNOLOGY ISSUE

A thoughtful but exuberant look at the innovative people, hardware, and software changing our world.

THE STATE OF TECHNOLOGY 02

By Steve Wozniak

A Gift We'd Be Happy to Get

The Om/One (\$199) by OM Audio is a Bluetooth speaker that hovers over a magnetic base in a small feat of audio engineering and modern design. The orb itself is the speaker that works independent of the base, so you can take it with you wherever you go. For more gift ideas, see page 41. And page 65. And page 123.



EJECTOR SEAT, NO. TOUCH-SCREEN, YES.

How is the new 2015 GMC Sierra 1500 the most advanced truck we've ever built? One way: touch-screen technology. Modern fighter jets use it to give pilots instant data and dynamic control. Sierra uses it, too, as part of the available 8-inch diagonal customizable LCD screen to give drivers instant data and dynamic response. And if it's capable enough for the speed of sound, it's capable enough for us. GMC Sierra. It's more than just a truck. It's incredible thinking in the form of a truck.

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Canon



WHEN INSPIRATION STRIKES, STRIKE FASTER.

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EOS 7D Mark II

PREAMBLE

LETTERS

For the record: On page 58 of the September issue, the figure for Ace Hardware's 2013 global retail sales should have read \$12 billion.

THERE ONCE WAS AN ISAAC ASIMOV FAN FROM INDIANA ...

The members of your sci-fi selection panel ("Science Fiction for Everyone," October) must have been teenagers. How else could they have ignored Isaac Asimov, the greatest science-fiction writer of all time? His Foundation series books alone should have qualified him. Then you could have also mentioned his irreverent non-sci-fi limericks in the story's footnotes.

TOM BRANUM SR.
Noblesville, Ind.

AND ONE MORE WORTHY SUGGESTION

You seem to have forgotten to include Clifford D. Simak in your list. His book *City* should be required reading for anybody who claims to love sci-fi. Actually, it should be required reading for anybody who claims to love great literature.

GEORGE ROTEN
Bloomington, Ill.

THE TECHNICIANS AT DEALERSHIPS WE'RE COOL WITH

I took offense to Spike Feresten's suggestion to avoid dealerships in "How to Buy a Car" (How Your World Works, October). As a retired technician for a dealership for 35 years, I can assure you that every job I turned out was quality.

GARY BARACKMAN
Melbourne, Fla.

Letters to the editor can be emailed to popularmechanics@hearst.com. Include your full name and address. Letters may be edited for length and clarity.

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ADDENDUM:
THE POPULAR
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← UNDERSTOOD, BUT LOOK OUT FOR THE JOCKSTRAP-TECHNOLOGY STORY SOON

As both a female engineer who regularly wears safety boots, and the handier person in my home, I was irritated that women's boots were omitted from your boot selector ("Fall Gear Special," October). Unless you're praising the latest advances in athletic supporters, realize you've got women in your audience and report accordingly. I would love to know which manufacturers are bringing safety boots for women to the table.

LAUREL M. JOHNSON
Sterling Heights, Mich.

THE OTHER CAR-SAFETY FEATURE

It wasn't until the last paragraph of Ezra Dyer's excellent article "The State of Car Safety" (October) that the real problem was addressed: We don't need safer cars; we need safer drivers. When people are in control of a 3,000-pound vehicle, they should be thinking of their driving and little else. If 33,000 people were killed in aircraft crashes every year as are killed in car accidents, something would be done about it, and it wouldn't be stronger airplanes.

JOHN SHOMIN
Liberal, Mo.

Something I would love to see improved is the rearview mirror. Many cars today have large blind spots in the back corners. But the bigger issue is making sure drivers are educated behind the wheel so that they rarely need all the "helpers" built into their cars.

GEORGE STAMM
Chippewa Falls, Wis.

THIS MONTH IN INSTAGRAM

Everyone must be cleaning out their grandparents' garages: (1) @weinbenlick, (2) @paintandpixels, (3) @jsdigital, (4) @katherine.forest, (5) @mediumcontrol, (6) @glamisyco.



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PREAMBLE



I JUST SAW THE NEW MOVIE ABOUT ALAN TURING, *The Imitation Game*, which we wrote about in the November issue. It's a riveting film, well worth seeing. Turing was the mathematical savant who cracked the Nazi Enigma code, helping the Allies win World War II. He also created the Turing test, a method for measuring a computer's ability to behave like a human. Turing wrote in his paper introducing the test (which he called the Imitation Game), "I propose to consider the question, can machines think?"

That was in 1950. Sixty-one years later we had Siri. Next year, if everything goes as planned, we will have Jibo, billed as the world's first family robot, which is on our cover and which you can read about on page 100. Jibo relays your texts, orders dinner, reminds you of appointments, takes photos when you ask it to. Its movements are fluid, even natural. It may revolutionize the way we interact with devices, or it may not, but it's a big, ambitious undertaking by a pioneer in the industry, and it's raising questions about where technology is going—or should go.

I asked Graham Moore, who wrote the screenplay for *The Imitation Game* (based on a book by Andrew Hodges), what Turing would have thought of social robotics. "He would have been a huge fan of Siri," he said. "For Alan Turing there was no core thing that makes you human or makes you intelligent. It was only what you were in other people's eyes."

Over the summer I went to Boston to meet Jibo's creator, Cynthia

Breazeal. She showed me a prototype, and I have to say, I want one. At least I think I do. Many people consider Breazeal a genius, and 4,800 people have preordered a Jibo. But there are plenty who think her project is misguided. They pontificate about whether Jibo will divorce us from our fellow humans, replacing actual interaction. Plenty of people thought Alan Turing was misguided, and that guy Steve Jobs—and that other guy, Steve Wozniak, who thinks about all of this in his essay that begins on page 2. But they kept working and, you know, we won the war, and Apple exists. I guess we'll see what happens next, but we're hopeful.

RYAN D'AGOSTINO,
EDITOR IN CHIEF



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ANNOUNCING: THE POPULAR MECHANICS HOME WORKSHOP CHALLENGE

For 113 years Popular Mechanics has pushed the limits of what we can achieve in our workshops, whether it's making a rolltop desk (January 1976) or shaving cream (September 2014). Throughout, we've always had the same goal: inspire craftsmanship and creativity.

Now we're putting the challenge to you—and there are prizes. A few times a year, you'll find a contest. The directions will be specific. Victory won't be easy. But just by giving it a shot, you will test and improve your skills at making, building, and creating. And you might win a socket set.

CONTEST NO. 1

Construct something using a single sheet of plywood.

PARAMETERS:

- Your item(s) must be made out of one 4 x 8-foot sheet of plywood.
- The plywood can be any type, and you can cut it as many times as you like.
- You're free to use any type of fastener. Glue, screws, nails, bolts, clips, hinges, and brackets are all okay.
- You can augment your project with wheels, handles, metal tubing, or any other sort of hardware, but no other lumber is permitted.



A little inspiration: a plywood umbrella. Cumbersome but functional.

PRIZE:

The winner will receive a DeWalt 108-Piece Mechanics Socket Set, and your project will appear in a future issue of Popular Mechanics. (See page 131 for rules.) Good luck, have fun, and don't forget your safety goggles.

Email your plans and a picture of the results to PMWorkshopChallenge@popularmechanics.com by January 13, 2015.

Official rules can be found at popularmechanics.com/workshopchallenge.

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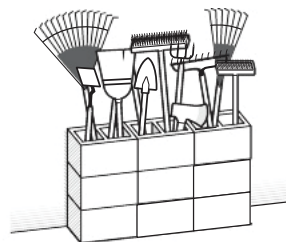
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PREAMBLE

READER TIP

Kevin Lindberg picked up this storage trick from his father-in-law, Ed Nista, of Brunswick, Maine: Stack cinder blocks three high and three wide for a remarkably stable way to store long-handled tools in your garage.



OUR FAVORITE ALUMNA: Elisha Cuthbert

On page 136 this month you'll find instructions for a project that you can build with a kid. We're calling it Popular Mechanics for Kids. But before there was the page in this magazine, there was *Popular Mechanics for Kids*, the educational TV show that ran from 1997 to 2001. The mainstay through all four seasons was Elisha Cuthbert, who would grow up to have a bona fide Hollywood career starring in *The Girl Next Door*, *24*, and *Happy Endings*. The first love of many a future engineer deigned to reminisce with us. — **MATT GOULET**

The show goes all the way back to 1997.

I was 15. Crazy, right? I've been acting for that long. The funny thing about *PMK* was that I was playing myself.

Did you know much about any of the subjects you were covering going in?

No, but I was really familiar with the magazine. My dad is an engineer, so he bought it. I've actually retained a lot from what I learned on the show, though.

Like what?

I know the inner workings of so many things. Like the sewer system. It's amazing how much I can talk about at a dinner table.

More than you would have learned in a classroom.

We got to meet real on-the-job people working their butts off to make the world run. We got to go up in a blimp. I was in a fucking blimp. I remember going to San Francisco and getting to see how a recycling plant worked. I know why I recycle now and where it goes. That is knowledge that sticks with you.

What happens at the recycling plant?

You recycle, it goes to a recycling plant. They separate paper, glass, plastic, and it goes into these machines, gets melted down and reused. You don't know that?

I thought it'd be more involved. You also filmed on an aircraft carrier.

The USS *Eisenhower*. Boat No. 69. That was one that Jay [Baruchel, her

cohost the first season and star of *This Is the End*] and I got to do together, which didn't always happen because he was off doing one thing and I was off doing another in most cases. It was one of the wildest things that I have ever done, probably to this day. We were catapulted off the carrier in a plane at the end to get us back home because the ship was out to sea for six months. That plane got going to, like, 300 miles an hour in 4 seconds.



Should you have kids of your own one day, will you be screening back episodes?

I may pull out a VHS. And they're gonna go, "What the hell is that?" I might have to track down, at least, some DVDs. I think I have every episode in my parents' basement on VHS. It's old-school, but it's good stuff.

Cuthbert's newest comedy, One Big Happy, where she plays a surrogate mom, will premiere midseason on NBC.





May your days be *airy...*



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WE GAVE CHILDREN TOYS AND THEN TOOK THEM AWAY, ALL IN THE NAME OF JOURNALISM.

In compiling our toy gift guide (page 65), the editorial offices of Popular Mechanics were inundated with products intended for children. It has been both embarrassing and fun. Some numbers behind the undertaking:

- 115 Estimated number of toys that were delivered to our offices.
- 15 Staffer's kids tasked with playing with (or testing) the products.
- 9 Paper airplanes that were folded before we could get one that would fly.
- 8 Estimated miles logged on the EzyRoller Classic up and down the office hallway.
- 1 Big thank you to Norman & Jules Toy Shop in Brooklyn, New York.

THE CREDENTIALS OF THE WOZ

The fella who introduced this issue, Steve Wozniak? He cofounded Apple with Steve Jobs and Ronald Wayne in 1976 and designed the Apple I and Apple II computers, ushering in the era of personal computing. If anyone could tell us whether we're truly living in a golden age of technology, it'd be him. The 64-year-old currently serves as the chief scientist for data storage company Fusion-io.

A BRIEF ADJURATION



STOP WORRYING ABOUT THE CURIOSITY ROVER Curiosity has holes in its wheels. Huge ones. In the two years Curiosity has been motoring around the planet, sharp rocks embedded in the surface of Mars have worn through the aluminum. But this is not a big deal. The mission achieved its goal—finding suitable conditions for life—almost immediately, so all the information NASA collects now is just a bonus. NASA estimates the Rover's nuclear power source will give out before its wheels do.

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1) Based on standard pickup class. EPA estimated 28 highway mpg based on EcoDiesel V6 4x2. Actual results may vary. 2) When properly equipped. 3) See dealer for a copy of the powertrain limited warranty. Ram is a registered trademark of Chrysler Group LLC.

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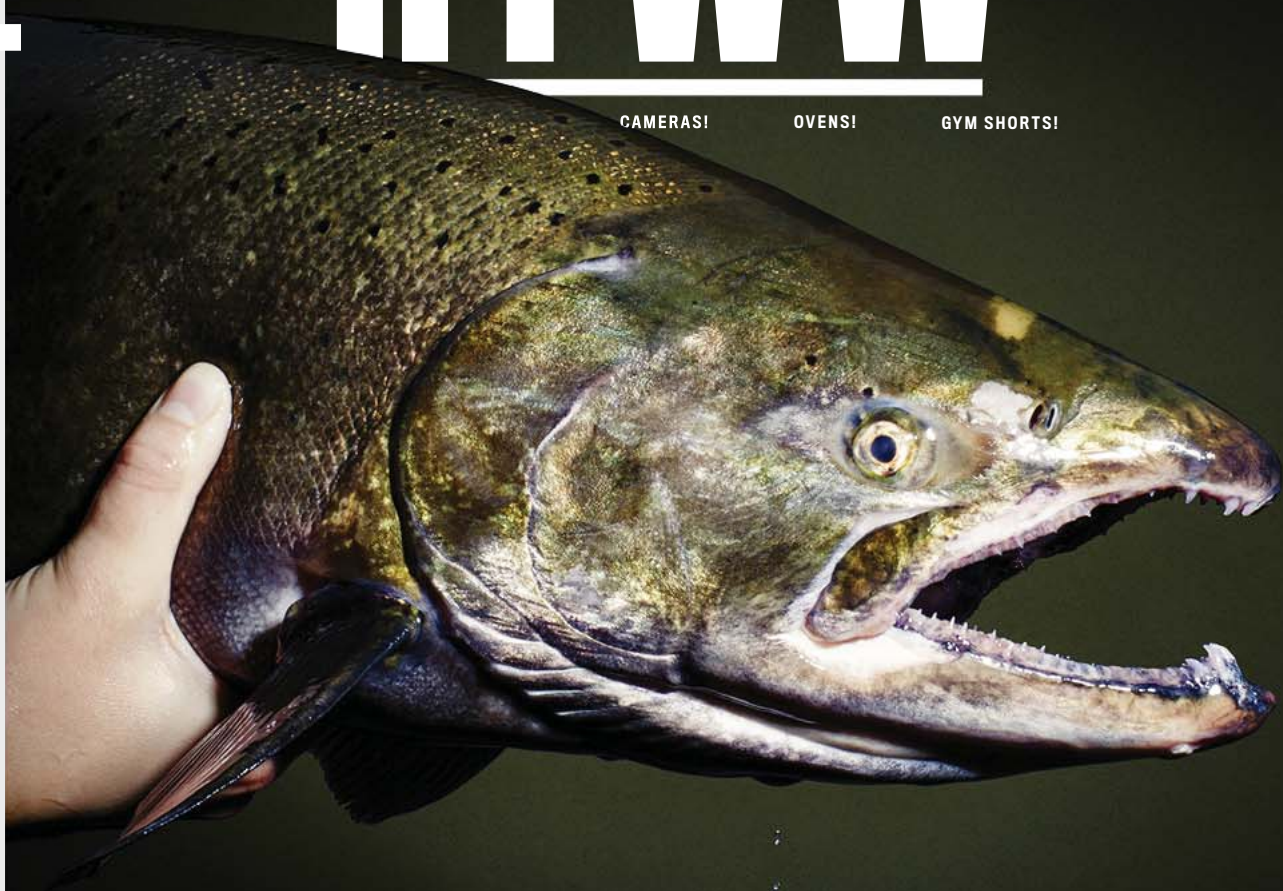
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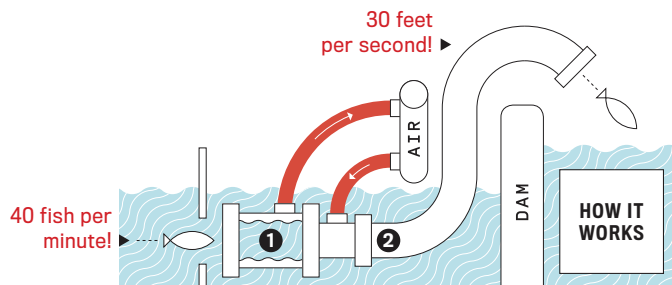
THE SALMON CANNON

Why launch a fish over a dam? Because we can. Also: Because it could save the environment.

BY CHRISTOPHER SOLOMON

NEAR AN OTHERWISE TRANQUIL Washington river, a bewildered Chinook salmon flops out of what looks like an air-conditioning duct, tail flapping fruitlessly. This is not an accident, or animal cruelty, or even a new way to deliver sushi. It is a moment engineered by man. Specifically, it is a moment engineered by a man with a cannon that shoots fish. It is also, one company hopes, the future of ecological conservation.

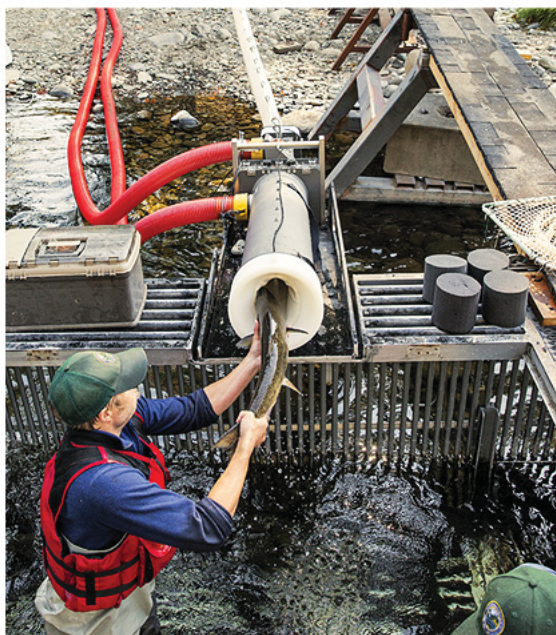
A salmon about to take a trip through the Whooshh Fish Transport System.



Fish are sucked into a conduit (1), then projected (2) up to 230 feet through a tube.

Whooshh Innovations, the fledgling transport company that launched the salmon, never planned for this moment. In the late 2000s it was struggling to gain a foothold in the agriculture industry. Whooshh had invented a tube that transported odd-shaped objects, like apples, from tree to bin without bruising them—a device much like the differential-pressure tubes they use in bank drive-throughs. Then, in 2009, Whooshh vice president Todd Deligan and CEO Vince Bryan III had a moment of entrepreneurial inspiration. They inserted a live tilapia into their machine. It zipped across the room, appearing Star Trek-like on the other side, unharmed and reasonably sanguine. The Whooshh Fish Transport System was born.

Around the office Whooshh executives call it the salmon cannon. But the transport system offers a cheap, clever, and lucrative solution to a serious problem. There are about 80,000 dams across the U.S., many of which block spawning salmon and steelhead trout far from the birthplaces they struggle to



return to. Fewer than 10 percent of these dams have built-in fish ladders, waterborne sets of stairs that help fish traverse the crevasse between the downstream river and the pool of water that sits above it. Conservation crews have tried all sorts of expensive

measures over the years to help salmon migrate across the dams without these ladders: barges, tankers, even helicopters. But never a cannon.

Though it can fire a fish 100 vertical feet at speeds of 30 feet per second, the salmon cannon doesn't usually blast its passengers over the ramparts. In Whooshh's fish lab, a garage in an industrial park in Bellevue, Washington, chief engineer Jim Otten explains how it works: A fish swims near an entrance, where a small blower of the sort that drives fans and belts sucks it into a flexible conduit. When the fish pushes through a valve, a tube attached to the blower introduces positive pressure behind the fish, which propels it into a moist, flexible, plastic sleeve, whose rubbery shape creates a seal. Off goes the fish. Otten inserts a big wet sponge into the machine to demonstrate. With a *ttthhwwwhpp*, the sponge disappears. Seven seconds and 130 feet later it plops out of the sleeve's other end.

The sponge (and the tilapia) seemed unchanged after shooting through the system, but regulators plan extensive tests to ensure that fish are safe inside it. The respected Pacific Northwest National Laboratory anticipates testing 40- and 250-foot-long fish cannons at a hatchery along the Columbia River, looking at factors like scale loss and egg viability, both of which affect whether a fish can go on to produce healthy offspring. If all goes well, the tubes could eventually become fixtures throughout the region, catapulting migrating fish over dams in constant streams like baseballs from an automatic pitch machine. No one tell the bears.

During a test on the Washougal River, an (undoubtedly confused) salmon is fed into the cannon.

The Fish in Question

This is a salmon. He was born in a river, and he'll return to that river to die. But first he'll change. Not as much as your ex-wife. Close, though.

PARR



Before migrating to the sea, small freshwater salmon, known as parrs, develop the necessary cells and enzymes to process salt water through their gills.

ADULT



Adult salmon live in the ocean for two to four years. About a year before spawning, they use an unidentified form of magnetic navigation to find their home stream.

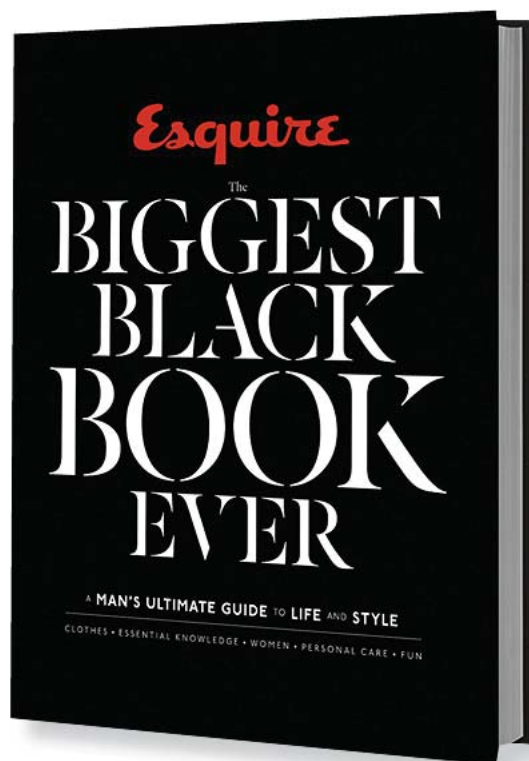
SPAWNING



At puberty, melanin and carotenoids redden and darken the salmon's skin. Males also develop a hump and a hooked jaw to fight off other males during spawning.

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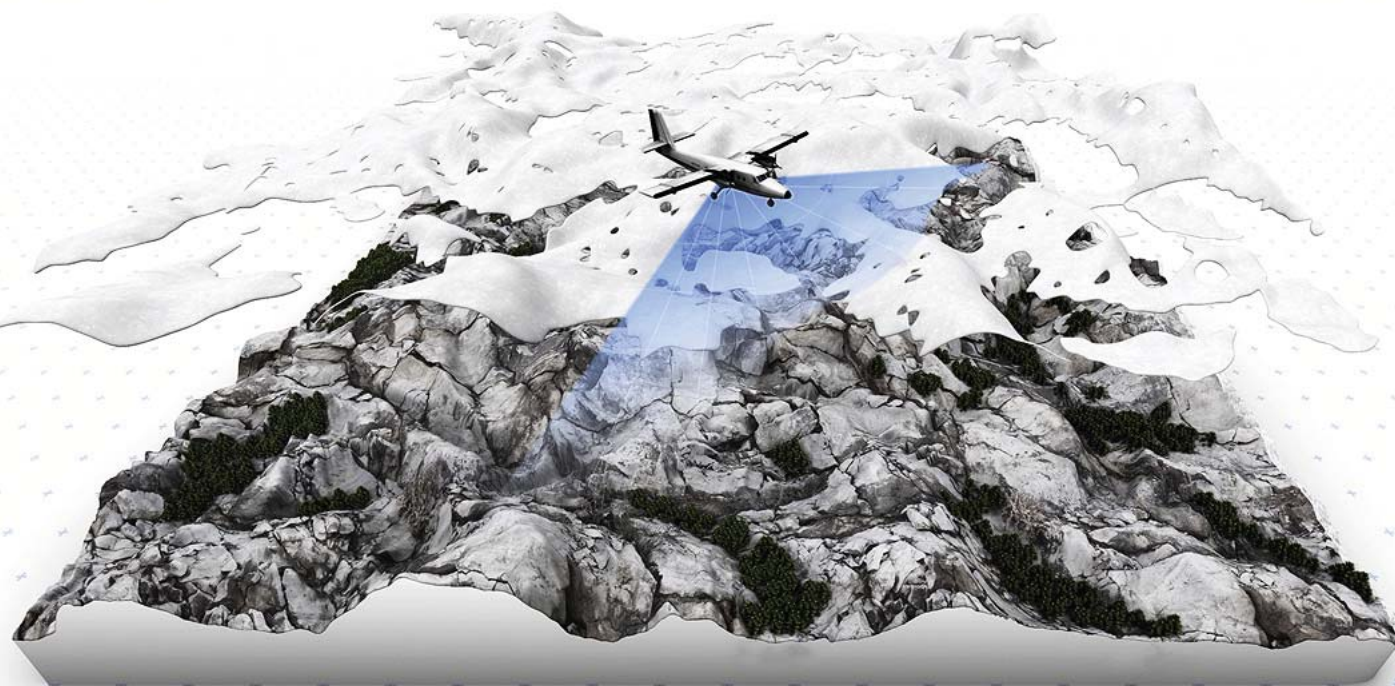
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THE SNOW PLANE

How a new way to measure snowpack is changing the drought in California. **BY RACHEL STURTZ**

ONE HUNDRED AND FIFTY miles outside San Francisco, a reprieve to the city's crippling water crisis could be falling from the sky right now: snow. When it eventually melts in the spring, the snowpack that piles up in the Tuolumne River Basin in the eastern Sierra Nevada Mountains will collect in the Hetch Hetchy reservoir before being doled out in San Francisco, directly determining just how much water will be available for every shower, lawn, and carbon-neutral backyard chicken coop in the city. But all that stored water helps only if city water managers know exactly how much is coming.

Two years ago NASA's Jet Propulsion Lab (JPL) teamed up with the California Department of Water Resources to create

the Airborne Snow Observatory (ASO), which allows researchers to predict spring runoff with much greater accuracy—and a lot less walking around in the snow with yardsticks. Led by JPL's Tom Painter, ASO trades manual ground surveys for a plane-mounted, dual-instrument system. The plane is rigged with an imaging spectrometer, which measures snow albedo—the melt rate, based on the amount of sunlight reflected and absorbed by the snow. It also has lidar, a pulsing infrared laser that determines snow depth, allowing researchers to calculate how much snow is there, and thus how much water it will create when melted (called snow-water equivalent, or SWE). Combining the two gives researchers the first-ever 3D model (above) of the

snow-covered mountains—and a good idea of just how much water flow city managers can expect in the summer.

ASO's accuracy is unprecedented, predicting snow depth to within 4 inches, and SWE to within 5 percent. And it's highly efficient: Researchers can cover 460 square miles (300,000 acres) in only 4 hours, and maps of basin-wide SWE and snow albedo can be created every 24 hours instead of once a month. As the ASO obtains aircraft that can go faster and higher, its acquisition times will drop even more. Ultimately, the goal is to place ASO instruments on satellites, or even the International Space Station, for global observation. The new technology may not be able to stop droughts, but at least it can help manage them.

And the Snow-Powered Subway

The Hetch Hetchy reservoir—a dammed-off valley in Yosemite National Park—releases 290 million gallons a day, servicing 2.6 million customers on the San Francisco Bay peninsula. The water's 167-mile trek generates enough hydroelectric energy to power local police and fire stations, along with most of the city's subway system.

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THE CASE FOR A CAMERA

Not a smartphone camera. A camera.

BY DAVEY ALBA

NOBODY CARRIES A SEPARATE CAMERA anymore, and that makes sense. Smartphone cameras have gotten good enough that, in most instances, they take perfectly passable photos. And they can't be beat for convenience.

But a smartphone will never be as good as a camera. It can't be. A quarter-inch slab of metal doesn't leave room for important features like lenses or large sensors—necessary things when you are shooting in less-than-ideal light or want to zoom in without hideous pixelation. The shots you want to get just right—the ones of your kids that you may want to one day appreciate on a screen larger than 2 x 5 inches—deserve to be taken on a real camera. Maybe one of these.

The most interesting point-and-shoot released this year is the **Canon PowerShot SX700 HS** (\$350). It has a sharp lens with a 30x zoom and, if you're so inclined, manual shooting modes that let you set shutter speed and aperture. It's also Wi-Fi enabled, so you can use your phone as a remote control to adjust zoom and flash, and trigger the camera.

One step up is **Sony's mirrorless A6000** (\$650). The 24.3-megapixel A6000 has an APS-C sensor that delivers a sharp image with very little noise (graininess), even in low light, and can capture a huge dynamic range. Plus, Sony claims the A6000's ultrafast autofocus system can lock in a subject within 0.06 seconds, which no phone could touch.

If you really want to take great photos, you need a DSLR. The new **Nikon D810** (\$3,300) is Nikon's highest-resolution camera, with a 36.3-megapixel full-frame sensor that produces the lowest image noise and widest dynamic range of any camera out there. Its 51-point focusing system, combined with a 5-fps capture speed, ensures you'll snap special moments with more reliability, whether you're shooting flag football or NASCAR. No way will it fit in your pocket, but neither will your car. And you wouldn't want your phone to replace that, either.



CASE STUDY

What good is a great photo if it stays on your camera? We printed a snapshot taken at this year's World Cup (below) using the best photo-printing options available, then had our photo editor judge them. Her findings:

CVS ★★ - Expensive. Slow. Shots look muddled.

Costco ★★★ - The cheapest online service—if you happen to be a member. Fast shipping, decent quality.

Epson XP-820 Printer ★★★★★ - Pricy (\$200), and can be a pain



to set up, but produced the richest colors and highest levels of contrast. Fast, too, printing a 4 x 6-inch image in 12 seconds.

Shutterfly.com ★★★★★ - Robust online editing tools, like cropping and effects. Good contrast, but photos take twice as long as Snapfish to get to you.

Snapfish.com ★★★★★ - The easiest of the online services. Great overall quality. Cheap and quick.

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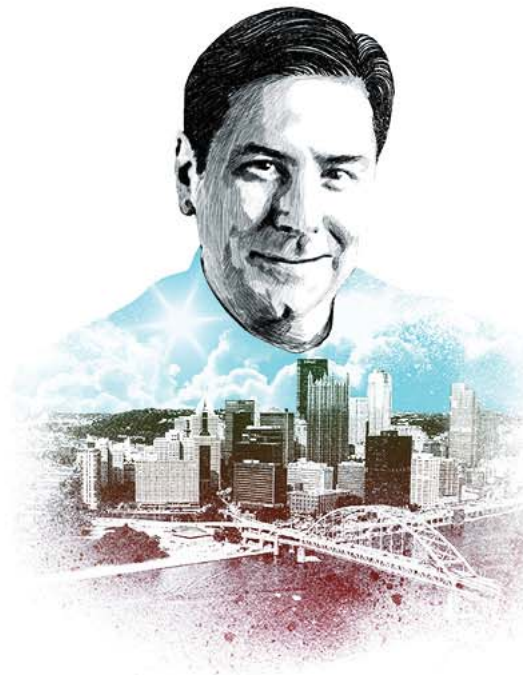
150 years

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THE MAKER MAYOR

Pittsburgh has become one of the most encouraging spots for innovation in the United States. We asked Mayor Bill Peduto how that happened.



POPULAR MECHANICS: No offense, but why Pittsburgh? Why is it suddenly a capital of the maker movement?

BILL PEDUTO: It's in our DNA. We have been making things since the days of the French and Indian War, when this was just a little fortress town in the western frontier. First it was glass. Then it was iron, then steel and aluminum. We basically built this country—every bridge and skyscraper of every city. That history is what separates us from Silicon Valley.

PM: Did you have to nudge the recent growth along? There was a bit of a lull after the steel industry shrank.

BP: It's taken awhile, but it was organic. Although big steel and big industry left the region, advanced manufacturing never did. In fact, in many ways it continued to grow as improved quality was needed to make up for the mass production that we were losing to Europe and Asia. Then, as the robotics industry started to take off, and Pitt and Carnegie Mellon University created the first robotics curriculum in the world, the demand was there to create the products designed in the classroom. And that led to companies like Google and TechShop opening up here in the last few years.

PM: Can any city do what you guys have done, or do you need certain infrastructure that's already there?

BP: Today's infrastructure is the talent. You need to be able to have that—the people who understand how to innovate and those who understand how to build the innovations.

PM: Is it getting easier to draw talent? Pittsburgh's reputation will never be like California's or New York City's.

BP: Twenty-somethings want the glamour of the coasts, but what we offer is more of a total quality of life. Instead of living in a cupboard, here you can actually afford to buy a home. The cost of the software engineer that you'll need to hire in Pittsburgh is a fraction of what you'd have to pay out in Silicon Valley.

PM: With all these new people and companies, have you seen small-business tax incentives actually working?

BP: We're seeing it work in the redevelopment of neighborhoods. When I first started working for the city in the mid-'90s, East Liberty was the drive-by capital of western Pennsylvania. Now it's a home to Google.

PM: But is all of this actually bringing in more money? Does the influx of workers help the city earn more money that it can then use to encourage growth?

BP: What we put back into the city from the increased revenue are protected bike lanes, open spaces and parks, and events. We make it so that this is a place where people want to stay, a place with vibrancy, and, hopefully, where they'll want to raise their family.

PM: What about concern that Pittsburgh lacks adequate venture capital?

BP: We have a VC community. It's obviously not as large as the others, but there is a support network

that comes out of the universities and groups like AlphaLab that are here to be able to take startups to the next phase. Once companies are looking for that 2 to 10 million dollars, that's where [we can improve]. There is an opportunity, though, for Pittsburgh's traditional corporations to help invest in the emerging community.

PM: And the winters aren't that bad?

BP: They're moderate. I like winter.

"We basically built this country—every bridge and skyscraper of every city."

CASE STUDY

Company: SolePower

Founded: 2012 by Carnegie Mellon University graduates Hahna Alexander and Matthew Stanton

Number of Employees: 7

Product: Inserts that convert footsteps into stored energy to charge cellphones and such.

Likely Clientele: Hikers, runners, and anyone in developing countries, where reliable power is often a commodity.



Why Pittsburgh:

Convenience. SolePower's manufacturers are all within 2 to 3 hours.

Launching: Spring 2015

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A SCULPTURE THAT HITS 800°

The wood-fired oven gets a New England makeover.

BY FRANCINE MAROUKIAN

ULTIMATELY, IT'S ABOUT FUNCTION. Nothing cooks food like a wood-fired oven. Eight hundred degrees of radiant heat and the penetrating power of woodsmoke leave a flavorful mark. But take one look at a Maine Wood Heat oven and the form is equally impressive: A gleaming copper dome designed by a Maine artisan sits atop an oven core made of highly reflective white clay found only in Larnage, France. "We've created a new identity for the traditional Parisian-style bread oven," says Scott Barden, who co-owns Maine Wood Heat, a second-generation family company.

Founded in 1976 by Barden's parents as an itinerant business installing ceramic-masonry heaters, which are integral to Yankee traits of thrift and self-reliance, Maine Wood Heat has evolved to focus on making wood-fired ovens at its shop in the central Maine town of Skowhegan, home to a thriving artist community. The company's signature products are ovens with handcrafted copper or steel caps for homes and restaurants. Each built-to-order oven can take 25 shop hours for the interior masonry portion and up to triple that time for the outer metalwork.

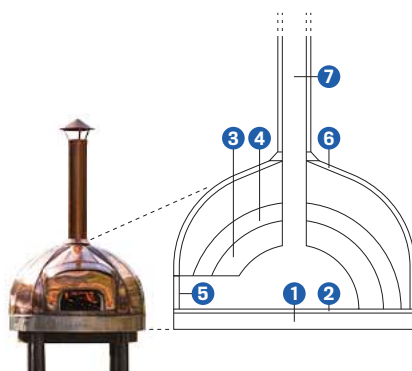
"The weatherproof copper facade



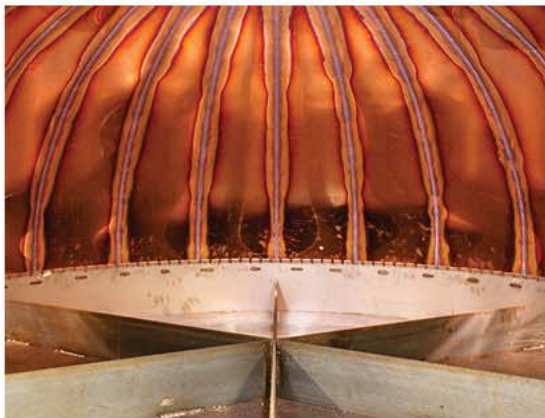
HOW IT WORKS

Anatomy of a Wood-Fired Oven

Wood-fired ovens rely on a balance of stored, reflected, and circulating heat to cook food at intense temperatures, directly and indirectly, with a live fire or warmth that remains days after the coals have been removed.



- 1. Pan:** 6 inches of mixed-material insulation.
- 2. Floor:** Fired tiles made of a food-safe, reflective white clay.
- 3. Ceramic dome:** Supplied by Le Panyol and made of the same clay as the floor tiles.
- 4. Dome cover:** A blanket of ceramic-wool insulation to trap heat.
- 5. Cast-iron firing door:** Regulates combustion and airflow.
- 6. Metal cap:** Copper or steel. For looks.
- 7. Chimney:** Copper or steel. If it's near anything combustible, an insulated pipe is safer.



From left: Scott Barden, co-owner of Maine Wood Heat, TIG-welds deoxidized copper rods to make smooth seams on the company's signature copper oven caps; inside each oven cap sits a Le Panyol white-clay oven hearth, shipped from France in pieces and then assembled at Maine Wood Heat's shop; a cap interior before the hearth is placed.

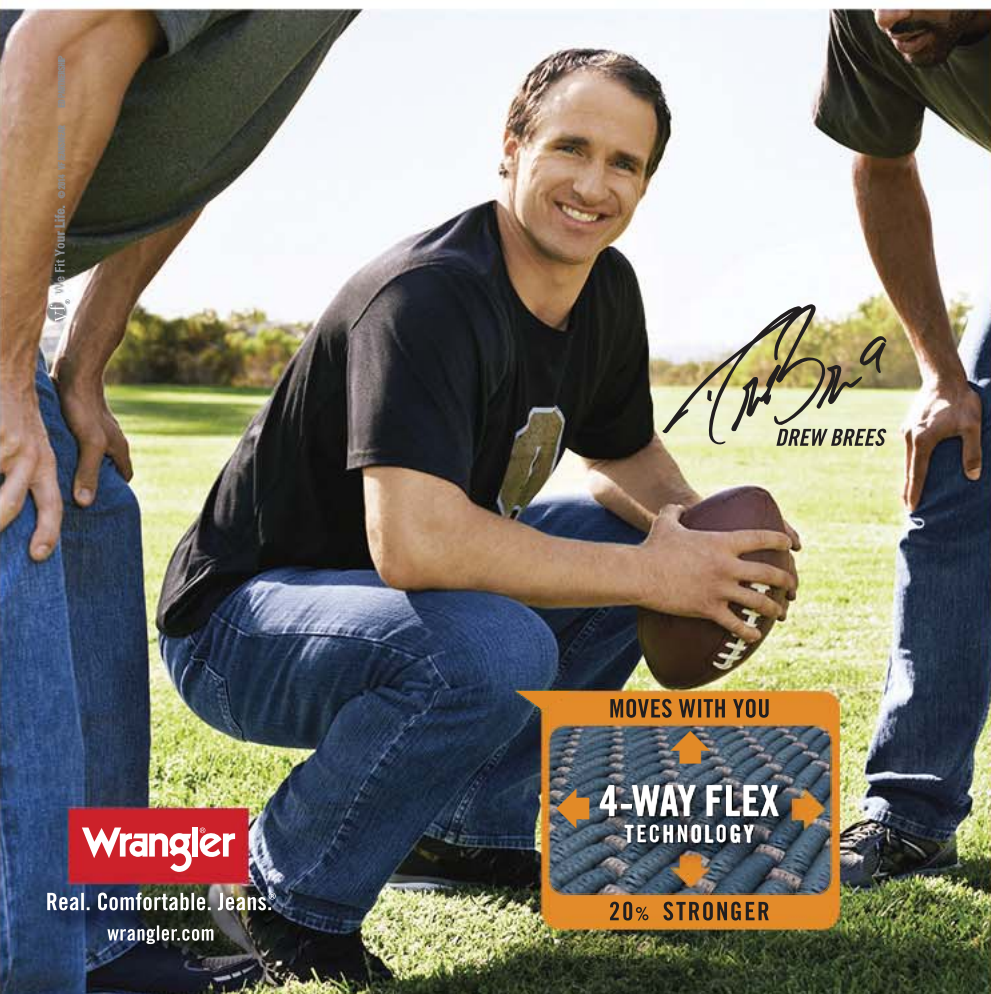
With its signature copper caps, Maine Wood Heat has created a new identity for the classic Parisian-style bread oven.

came from an early idea of my father's," Barden says. That idea was to have family friend and local metal sculptor Barry Norling create the template for a copper oven cap. Norling, known locally for his creative copper weather vanes, a significant feature of New England's colonial architecture, still makes most of the company's copper caps, signing every one he completes.

The heart of each Maine Wood Heat oven is a ceramic core supplied by 174-year-old French ovenmaker Le Panyol. For optimum cooking, each core is constructed of Terre Blanche de Larnage, a fast-heating white clay that remains food-safe at the highest temperatures. Made for kitchens or outdoors, the ovens are available in various sizes; the most common residential oven has a diameter of almost 33 inches and costs \$14,500, including shipping. What you get: a piece of art

that will bake 50 pizzas an hour and retain usable cooking temperatures for days after the last coals are removed.

For Barden, who now largely focuses on cap designs, inspiration is everywhere. Recently, while driving through Midwestern farmland, a corn silo gave him the idea to marry fired antique tile and aged steel. At this point it's just a fantasy: He wants to make it because it's beautiful. But with the right assembly, he also hopes that it can cook.



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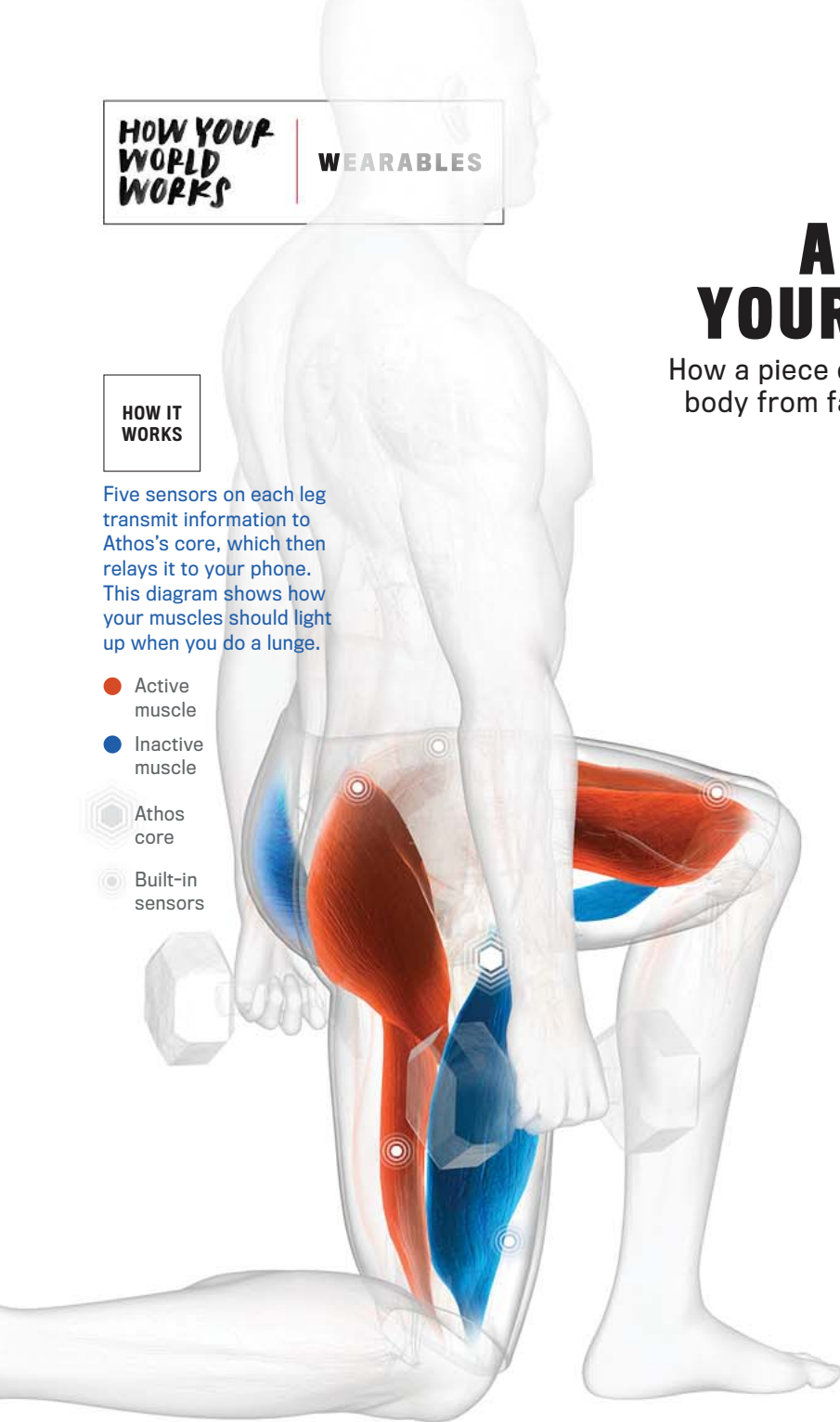
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HOW IT
WORKS

Five sensors on each leg transmit information to Athos's core, which then relays it to your phone. This diagram shows how your muscles should light up when you do a lunge.

- Active muscle
- Inactive muscle
- ⬡ Athos core
- ⊙ Built-in sensors



And One on Your Forearm

The **Push Strength Tracker** (\$189) has one big advantage over wearables like Fitbit and NikeFuel: It does something legitimately useful. Slide the cuff over your forearm, sync to an app, and Push records every rep, constantly measuring force, speed, and power in order to let you know when to lift heavier or lighter, faster or slower. The power light is a little bright and unsubtle, but so was spandex, and people got through that.

A COMPUTER IN YOUR GYM SHORTS

How a piece of workout gear could keep your body from falling apart. BY JACQUELINE DETWILER

HAVE A BAD LEG, LIKE A CHARACTER IN A

Dickens novel, only I got it by dancing ballet. Alone. In my bedroom. I was 16 and practicing a move called a penchée when my right hamstring made a sound like the end of a string bean snapping off. I had to use crutches for six weeks and, because I couldn't sit comfortably in any of the usual configurations, rode everywhere in the back of the family pickup.

More than a decade later this one injury has caused every other muscle in my right leg to self-destruct. It's responsible for hip flexor tendonitis, sprained ankles, runner's knee, and a case of IT band syndrome. This is the sad truth of living in a body made up of complementary muscular circuits: Tear one lousy hamstring and you spend the rest of your life keeping watch against the avalanches of pain that poor alignment sends caroming down your beleaguered skeleton.

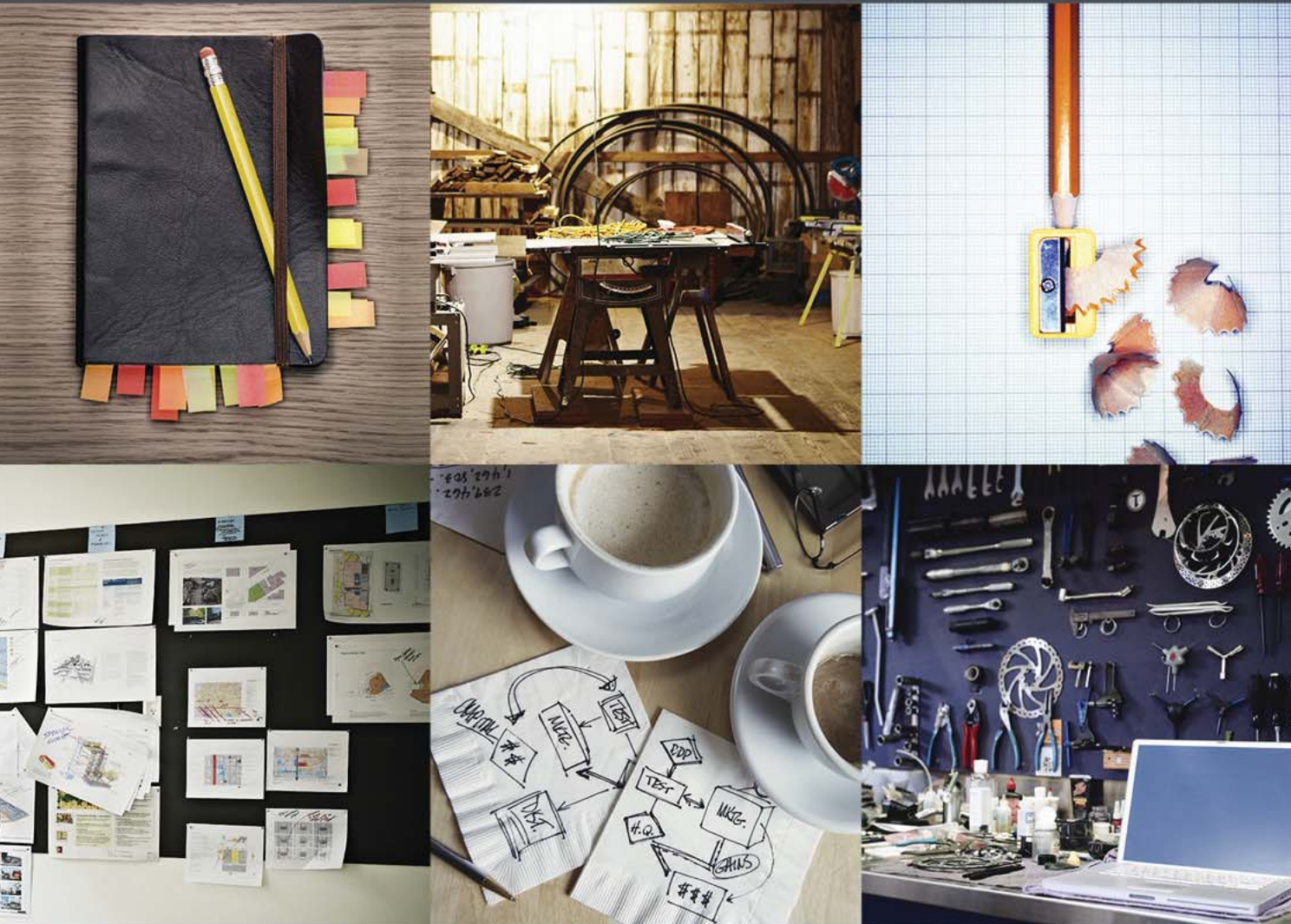
This is why I would actually use Athos's new EMG shorts (\$99, plus \$199 for a plastic core that transmits to a free iPhone app). EMG stands for electromyography, a method of measuring the electrical signal that motor nerves send to muscle fibers to make them contract. The stronger the signal, the more muscle fibers are being recruited, and the harder the muscle is working. EMG is normally available only to elite athletes, but Athos has worked it into a pair of shorts for regular humans. Once the shorts are on and calibrated, a tiny, light-up version of your body appears on the app. As your muscles work harder, the inner and outer quads, hamstrings, and glutes on the screen change color, from blue to red.

The app can show you, in real time, how tiny imbalances in form and strength can wreak havoc across your entire muscular system—as well as how to fix them. Wearing the shorts is like having a personal trainer with X-ray vision. Lean too far forward in a lunge and the opposite hamstring stops lighting up. Slack off during squats and your glutes never go full red. I had to go to Olympic lengths to get my useless right hamstring out of the blue-green zone. But at least I could finally see the path toward fixing it.

PROMOTION

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HOW'D THEY GET THAT SHOT?

EXODUS: GODS AND KINGS

Director Ridley Scott's epic new reimagining of the biblical story of Moses (out December 12) stars Christian Bale and Joel Edgerton—and a whole lot of CG magic. Visual-effects supervisor Peter Chiang shares how it was done.

In this scene Ramses and his army pursue Moses and the Jews as they flee Egypt. Everything from the pillars to the trumpeters is real. It was shot on the lot at Pinewood Studios in London on a cloudy day. The shadow line you see in front of the trumpeters marks the edge of the Pinewood shot.

The troops in the main aisle are also real, but they were reshoot in Fuerteventura, Spain, after Ridley decided the scene didn't work without sunlight. When we got to Fuerteventura, the crane didn't rise as high as it did in Pinewood, so we had to manipulate everything a bit, digitally, to get the perspective to work.

Ninety percent of the soldiers are CG. We digitally built models of horses and chariots, and simulated cloth flags, dust, hooves, and wheels to blend in seamlessly with the live action. Complicating all of this is the fact that we shot in 3D, so everything had to be done from two angles. There's no cheating or simply painting a scene.

If a chariot had been in the foreground, between the drummers and trumpeters, we would have had to do it computer-controlled to get the perspective exactly the same. But when objects are a certain distance away, like this, you get a bit of leeway with the perspective.



The sphinxes were originally shot in Pinewood, but they were also in flat light, so we had to rebuild them in CG, light them properly, and place them in the scene.

The overcast sky was added later on Ridley's direction to heighten the drama.

Those birds are CG. Ridley suggested them.

BEFORE

AFTER



To shoot in Spain, we needed to know where these digital sphinxes were so we didn't have horses and chariots riding through them. We marked out the corners of each sphinx and statue, in the dirt, with green wooden posts.

In the movie you'll see the scene swing around in reverse. Since the columns were built only 10 to 15 feet high, we had to add the rest in CG.



WHAT DO PILOTS TALK ABOUT ON LONG FLIGHTS?

AIRLINE PILOTS ARE RIGOROUSLY TRAINED, HIGHLY-skilled professionals. During long flights they may pass the time performing complex weight and balance calculations in their heads or quizzing one another on arcane emergency checklists. Generally, though, they do what workers in any profession do when they're out of earshot of the boss man: They gossip about their coworkers and bitch about management.

In fairness, golf, fishing, and girls are also popular topics, according to Patrick Smith, a pilot and author of *Cockpit Confidential*, a book about life behind the controls. Airborne gabfests ("nonessential communication," in the parlance of the trade) are restricted by the Federal Aviation Administration's "sterile cockpit rule" to certain phases of flight—namely, above 10,000 feet, just like the

use of your electronic devices back in the Sardine-o-Riffic Economy section. Indeed, idle cockpit chit-chat at critical times has resulted in near collisions, flights at incorrect altitudes, or attempted landings on incorrect runways and even at incorrect airports, which may explain how anybody ever ends up in Wichita.

Occasionally the cockpit voice recorder will memorialize something untoward—jokes before a fatal accident in Buffalo, New York, in 2009; snoring before a 2010 Air India crash—but bear in mind that the tapes are not checked as a matter of course. If cockpit recordings are under review it probably means the pilot has suffered a fate far worse than embarrassment.

Why do you have to sign your name on those little machines when you pay with a credit card at the supermarket? It's

always illegible, and nobody checks it against your card, so what's the point?

Like so many of the arbitrary indignities to which we are subjected at the hands of authority, the signature charade is ostensibly played out "for your protection." In theory the cashier should compare the scrawl on the screen to that on the back of your card to establish that your card has not been swiped in more ways than one. In practice this almost never happens—and even if it did, as you note, the output of the typical stylus on the typical sensor screen is the graphological equivalent of a lusty fart on a hardwood bench.

No matter. The fraud-detection algorithms employed by credit card issuers have become adept at detecting bogus transactions whether or not anybody signs anything.

So why do they still ask you to sign? A few reasons—none of which actually benefits you. Signatures are important to vendors because they pay higher commissions on sales without them and they bear a greater risk of getting stuck with the cost of a fraudulent charge if they can't produce a signed receipt. Moreover, if you incur a charge that somehow "slips your mind" and results in a dispute, the credit card company can "jog your memory" by showing you the scrawl on that tab from the Platinum Kitty High-Class Gentleman's Booty Bar and Buffet, which it assumes you are able to recognize as your own, no matter how carefully you tried to forge your boss's name.

It is said that the camera adds 10 pounds. Is there any scientific basis to that claim?

The bacon cheeseburgers add 10 pounds. The camera merely reveals this stark truth more efficiently than the human eye. How? Let us count the ways.

In real life we tend to see ourselves several times a day,



every day, so we may not notice the insidious encroachment of middle-age spread. Freeze a moment in time and examine it in isolation and it's suddenly, "Dang, when did I get so fat?" Lighting plays a role, as well. Usually parts of our faces or bodies are shadowed, which helps define edges and contours. A flash photograph,

which fills in those voids, can flatten—and thereby fatten—us.

Moreover, we're used to seeing ourselves and others from certain conventional distances. Alter those apparent distances and a person's looks can change. That's because the brain assesses the size of a face by using the distance between fea-

tures seen from a typical vantage point to establish scale. Change the ratios substantially and the brain interprets a person's appearance differently. Rule of thumb: The closer you are to the camera, the thinner you'll look.

Finally, the fact that we have two eyes, whereas the camera has only one, works against us. Our two-eyed view contains more background than a typical camera lens captures. An object looks larger against the camera's seemingly smaller background, and vice versa. So try to pose in front of, say, the national debt.

Do you have unusual questions about the world and how it works and why stuff happens? This is the place to ask them. Don't be afraid. Nobody will laugh at you here.

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Questions will be selected based on quality or at our whim.

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THE ALL-TECH GIFT GUIDE

27 gadgets—and one cutting-edge
jacket—thoroughly tested
and all but guaranteed to improve the
lives of the people you care about.

PHOTOGRAPHS BY WILL STYER



Speakers



1. JBL CHARGE 2 (\$150) • A Bluetooth speaker with dual drivers and twin passive radiators that delivers room-filling sound with decent bass. The battery lasts 12 hours, and you can charge another device through the USB port.

2. SOL REPUBLIC PUNK (\$70) Good sound, good price, and small enough to pocket.

3. AETHER CONE (\$399) A Wi-Fi speaker that thinks, sort of. Press a button in the center of the speaker grille—or

simply talk to it—and it streams from either Rdio (for music) or Stitcher (for radio and podcasts). If you don't like the track, spin the outer ring. A small twist plays a similar-sounding song; a big spin changes the genre.

**GIFTING TIP!**

Before you buy something on the Web, always Google online coupons. Or do your shopping through ebates.com, a portal to 1,700 participating stores that gives you cash back (usually 3 to 6 percent) on everything you buy.

Headphones and Earbuds

1. JABRA SPORT PULSE WIRELESS (\$200) • The first wireless buds to integrate real-time voice coaching, plus a heart-rate monitor and a motion sensor to pick up on exercise intensity.

2. SHURE SRH1540 (\$500) • The SRH1540s are huge. But they're also comfortable and surprisingly lightweight. The headphones' 40-mm drivers deliver sound so accurate, it's like you're sitting in the studio.

3. MERKURY URBAN BEATZ TEMPO (\$20) • Far from the best option, but sound quality is decent—and for \$20, they're nearly disposable.

4. BOSE QUIETCOMFORT 25 (\$300) • The new QC25s have the same excellent noise-canceling system as their predecessors but with fuller bass, plus the ability to continue to play music when the batteries die.

5. BOWERS & WILKINS C5 SERIES 2 (\$180) • The updated C5 Series 2 are 10 percent lighter and have new drivers that make them sound even better than the originals. For the same price.

6. MASTER & DYNAMIC MH40 (\$400) • An alternative to plastic headphones, the MH40s are made of forged aluminum and real lambskin leather. (They smell like it too.)

If you stop looking at them long enough to put them on, the bass is amazing.

7. NUFORCE PRIMO 8 (\$500) You will struggle a bit to get a good seal, but it's worth it: Four balanced-armature drivers produce almost the same quality you'd hear live. Detachable cables are a plus, since you won't need to replace the entire headphone if they break.

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Accessories

1. **TOSHIBA CHROMEBOOK 2 (\$330)**

• A cloud-based laptop stripped down to only the essentials. Toshiba's Chromebook gives you a pixel-dense 13.3-inch 1080p IPS display with good contrast and wide viewing angles. It also comes with Skullcandy-branded speakers that deliver better sound than other options in the same price range.

2. **SPRINT LIVEPRO PRO-JECTOR (\$450, \$35/month fee)**

• The idea is great, if expensive: A battery-powered projector with a built-in speaker and cell service means not having to lug around much equipment to turn your backyard into an outdoor theater. Download a movie from Google Play directly to the LivePro, cue it up on the 4-inch touchscreen, and project an image as big as 10 feet (diagonally). All you need is a sheet.

3. **TRANSPORTER STORAGE DEVICE (\$200 for 500 GB)**

Cloud storage gives you access to your files anytime and anywhere, but cloud storage is not always secure. With the Transporter, you don't have to worry. Sync the device directly to your router, and all your files are encrypted in your own personal cloud. Then, get remote access through mobile and desktop portals.

4. **WD MY PASSPORT WIRELESS EXTERNAL DRIVE (\$130 for 500 GB)**

A portable hard drive with a built-in SD card reader is a great gift for shutterbugs. Insert any memory card into the drive and you get access to it on your phone, tablet, or computer through a free app. You can set it so the card automatically transfers files and is wiped clean. Up to eight people can connect to the drive simultaneously.

1

2

3

4

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**GIFTING TIP!**

ReturnGuru (iOS, Windows Phone) lets you snap photos of your gift receipts, then reminds you before the return periods expire in case you want to take anything back.



Smartphone Accessories



1. UNE BOBINE (\$35) • A stiff smartphone-charging cable that also serves as a flexible stand. Use it as a dock or a tripod or a sturdy coil for a video-chat session.

2. NATIVE UNION JUMP CABLE (\$50) A charging cable that has a built-in battery, for those times you can't find somewhere to plug in. The 800-mAh capacity gets you through 3 additional hours.

3. BELKIN BOOST UP CHARGER (\$40) With its 12-watt/2.4-amp power output, Boost Up delivers 40 percent faster charging than the typical 5-watt mobile charger. A great gift for travelers.

4. PHONESUIT ELITE (\$89) • Unlike most battery cases, the Elite is actually attractive. That it gives you 120 percent more power for the day is just a bonus. Versions for the iPhone 6, the iPhone 6

Plus, and the Samsung Galaxy S5 are on their way.

5. UNU ULTRAPAK GO (\$60) • A 3,000-mAh portable battery that recharges itself in less than 30 minutes—up to eight times faster than other options.

6. BOLT CHARGER (\$60) • There's a battery built in to this mod wall charger, and it has nearly four times the capacity of the JUMP Cable (3,000-mAh).

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Outdoor Gear



TECH GIFT GUIDE

1. MOUNTAIN HARDWEAR GHOST WHISPERER JACKET (\$320) • At 7 ounces, Ghost Whisperer is the lightest down jacket in the world. It's also windproof and water-repellent, and packs into its own pocket.

2. TOMTOM RUNNER CARDIO (\$270) • By measuring blood flow through your wrist, the TomTom is the only high-end heart-rate monitor we've seen that doesn't require a chest

strap. Which means you can finally keep your heart pumping at the right pace without getting a rash.

3. TAD GEAR SKELETON KEY (\$99) • Add it to your key chain. Open anything. The key includes a bottle opener, pry bar with nail pry, hex wrench, and flat-head screwdriver.

4. POLAROID CUBE CAMERA (\$100) • This weatherproof cube uses a built-in magnet to stick to any metal surface.

It shoots up to 90 minutes of 1080p video with a 124-degree wide-angle lens. Great for getting POV shots on vacation or at a pool party.

5. ZOJIRUSHI STAINLESS MUG (16 oz, \$40) • Keeps drinks hot or cold for up to 6 hours, with a slim silhouette that fits easily in your hand (or bag).

6. SCHWINN CYCLENAV (\$60) A GPS for bikes, the CycleNav mounts to the handlebars and relays turn-by-turn directions

(both audibly and by lighting up as a turn signal) from Schwinn's phone app via Bluetooth. It even doubles as a headlight.

7. WITHINGS ACTIVITÉ (\$390) Most fitness trackers are horribly ugly. But the Activité tracks your steps, sleep, and calories while looking like an actual watch. For the fitness-minded woman in your life the Tory Burch bracelet (not pictured; \$195) hides the clunky Fitbit in a bangle suitable for a night out.





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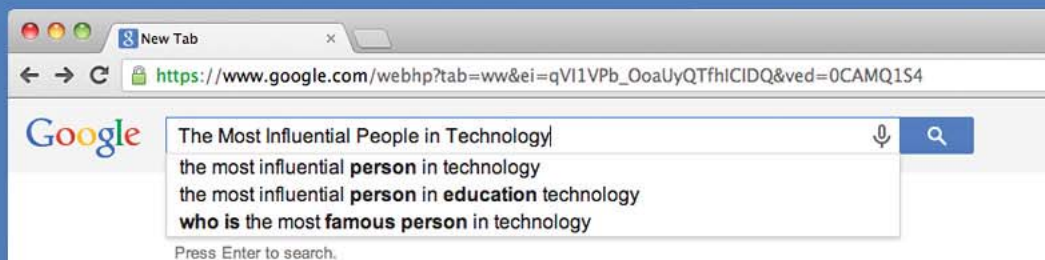
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THE MOST INFLUENTIAL PEOPLE IN TECHNOLOGY YOU'VE NEVER HEARD OF

There isn't a household name in the bunch, but these 12 innovators play huge roles in shaping the way we live—in the digital realm and beyond.



NAME Jeff Dean, 46

LOCATION Palo Alto, California

TITLE Google senior fellow

AT GOOGLE, AMONG

those who make the search engine go, Dean is a near-deity. Apart from getting credit for codesigning the core query system, he built some of the programming infrastructure that sits beneath Google Translate and other products. He's so revered that on one April Fool's Day, an engineer set up a website so employees could riff on his coding prowess. (Typical submission: "The speed of light in a vacuum used to be about 35 mph. Then Jeff Dean spent a weekend optimizing physics.") Dean, who was hired when Google employed about 25 people, leads the spadework that makes the firm run, but says he hasn't done anything on his own. His team once built a neural network that taught itself to recognize cats from 10 million YouTube images. Next up: Dean is exploring computer vision, natural language understanding, and machine-learning systems for image and speech processing. — D.A.

INFLUENTIAL PEOPLE



NAME Judge Lucy H. Koh, 46

LOCATION San Jose, California

TITLE Judge, United States District Court

"Unless you're smoking crack, you know these witnesses aren't going to be called," Koh snapped when an Apple lawyer handed her a long list of witnesses with just 4 hours of testimony to go.

During her four years on the bench in U.S. District Court in San Jose, Koh has become Silicon Valley's referee. She has decided, among other seminal rulings, whether Google can read your emails (it can, but not if you're a school, business, or government customer), and which smartphones you can buy. She spurned Apple's request to ban sales of Samsung smartphones after a jury found Samsung guilty of patent infringement, and ruled that Google hadn't stated clearly in its terms of service that it scans users' email to deliver targeted ads. Last August, in a suit alleging that four companies—Apple, Google, Intel, and Adobe—colluded to hold down wages by not hiring each other's employees, Koh rejected a \$324.5 million settlement she deemed too low. A former federal prosecutor, Koh displays an almost superhuman ability to move cases along. With as many as 350 on her docket at times, she has little patience for lawyers who gum up the process. Her jurisprudence has inspired an Internet meme and

launched a Wikipedia editing war. "She's the most important person on the bench dealing with Internet technologies in the country today," says Tracy Beth Mitrano, director of the Institute for Internet Culture, Policy, and Law at Cornell University. "She has not been starstruck by the influence and power of corporations." Koh's commitment to expedient justice helps firms avoid getting bogged down in courts—and pushes them to operate with more transparency. — DAVEY ALBA



NAME Loren Brichter, 30

LOCATION Philadelphia

TITLE App designer

YOU KNOW HOW WHEN you want to check for new email or tweets on your iPhone, you pull down the page and it automatically refreshes? Brichter invented that, along with a whole lot of other stuff you use every day but rarely think about. "To quote Einstein, 'Everything should be as simple as possible, but no simpler,'" he says. Brichter also created the addicting word-strategy game Letterpress, which he says was a kind of pilot test for a new style of programming he hopes to release soon. "The problem with programming now isn't that you're an idiot, it's that the language is too complicated," Brichter says. Just 30, he has already helped make even the most granular parts of the digital world more elegant and user-friendly. — BILL GIFFORD

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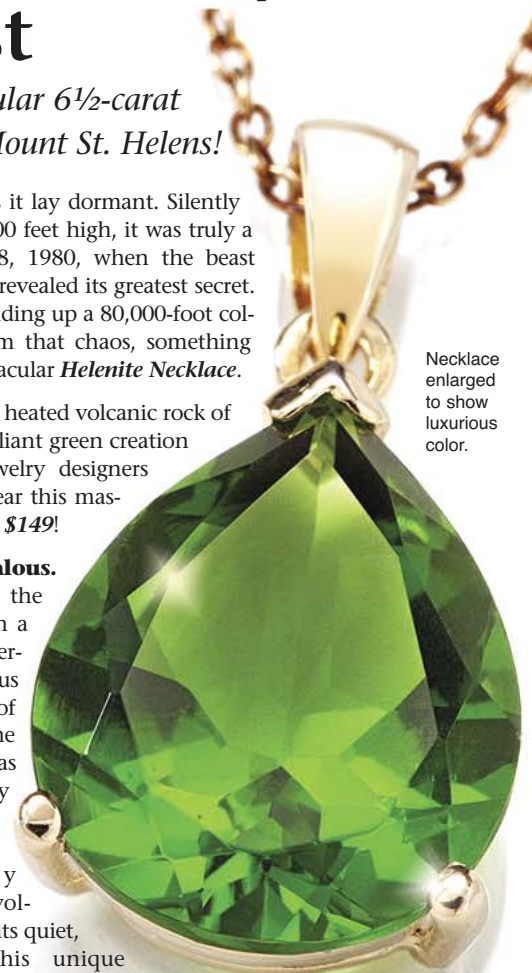
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Young fans of online video stars scream at a DigiFest concert in June, New York City.



NAME Meridith Valiando Rojas, 30
LOCATION Los Angeles
TITLE CEO, DigiTour Media



"IF YOU'RE NOT A TEENAGE GIRL," you've probably never heard of our stars," says Valiando Rojas. Her business creates and produces tours and festivals that put YouTube and Vine influencers with huge followings—like the hip-hop duo Jack and Jack (4.5 million Vine followers) and sketch-comedy artist Matthew Espinosa (4.4 million)—onstage in front of hordes of 13-year-olds. Ticket sales for the IRL (in real life) social-media shows will hit 300,000 next year. "There are thousands of phones in the air, there's hysterical screaming, there's fainting," she says. Valiando Rojas got her start developing talent at Columbia Records while she was still a sophomore at New York University, took a top job at Spirit Records two years later, and founded DigiTour at 25. The festivals include comedy, music, short skits, improv, and more, and the longer events pack 80 artists into 8 hours. "It's very ADD," she says, "but we're just re-creating the way kids consume media on a daily basis." In the old days a performer would play gigs as a way to get a record deal and shoot a video; now it's the other way around, as YouTube is often the first step—the building block to lucrative contracts and concert stages. By flipping the model on its head, DigiTour has become a fresher version of the way reality shows minted new celebrities in the early 2000s. Valiando Rojas's performers are about to spill over into the mainstream, appearing on TV shows, commercials, and more. This will baffle some viewers—you can already hear the grownups asking, *Who are these people?* But teenagers are technological tastemakers. So in a real way, Valiando Rojas is shaping the future of entertainment. — EVELYN SPENCE



NAME Megan Smith, 50
LOCATION Washington, D.C.
TITLE U.S. Chief Technology Officer

IN SEPTEMBER THE OBAMA administration chose Smith, a Google X vice president and MIT-trained mechanical engineer, to be technologist-in-chief. The obvious reasons were her business savvy and direct line to Mountain View—she led acquisitions that became Google Maps, Google Earth, and Picasa. And her gigs at both Google's philanthropic arm and PlanetOut, a now-defunct online LGBT media company, suggest technology might become more inclusive under her watch. But Smith's true strength may be her passion for moon-shot ideas—the kind that led to Solve for X (a three-day brainstorm with the world's most powerful minds) and Google's Project Loon (Internet connectivity by balloon) and Project Wing (delivery by drone). — E.S.



NAME Michael Eisenberg, 43
LOCATION Jerusalem
TITLE Equal Partner, Aleph

ISRAEL ISN'T nicknamed Silicon Wadi for nothing: It has more startups per capita than any nation and boasts 66 companies on NASDAQ—more than India or Japan. "Like all great entrepreneurs, we're resilient and optimistic," says Eisenberg, who cofounded the \$140 million venture fund Aleph last year. He believes a solid economy builds stability, so he incubates firms that will stay in Israel even as they become relevant worldwide. "The next step is to become a scale-up nation," he says. Aleph's first steps are promising: One early get, Freightos, may alter global freight the way Expedia changed travel, by providing real-time quotes; another, JoyTunes, aims to enrich music education with iPad apps. The notion that prosperity really does equal stability—maybe Eisenberg can export that too. — E.S.



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 - d. (1) Free or Nominal Rate Outside-Country Copies Included on PS Form 3541: 372,390
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 - e. Total Free or Nominal Rate Distribution (Sum of 15d (1), (2), (3) and (4)): 377,079
 - f. Total Distribution (Sum of 15c and 15e): 1,150,794
 - g. Copies Not Distributed: 160,461
 - h. Total (Sum of 15f and g): 1,311,255
 - i. Percent Paid (15c divided by 15f times 100): 67.2%

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- a. Total Number of Copies (Net Press Run): 1,292,350
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 - (2) Mailed In-Country Paid Subscriptions Stated on PS Form 3541: n/a
 - (3) Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS: 56,000
 - (4) Paid Distribution by Other Classes of Mail Through the USPS: n/a
 - c. Total Paid Distribution (Sum of 15b (1), (2), (3), and (4)): 757,956
 - d. (1) Free or Nominal Rate Outside-Country Copies Included on PS Form 3541: 368,644
 - (2) Free or Nominal Rate In-Country Copies Included on PS Form 3541: n/a
 - (3) Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail): n/a
 - (4) Free or Nominal Rate Distribution Outside the Mail (Carriers or other means): 3,727
 - e. Total Free or Nominal Rate Distribution (Sum of 15d (1), (2), (3) and (4)): 372,371
 - f. Total Distribution (Sum of 15c and 15e): 1,130,327
 - g. Copies Not Distributed: 162,023
 - h. Total (Sum of 15f and g): 1,292,350
 - i. Percent Paid (15c divided by 15f times 100): 67.1%

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- a. Requested And Paid Electronic Copies: 68,290
 - b. Total Requested and Paid Print Copies and Requested/Paid Electronic Copies (Line 16c): 842,005
 - c. Total Requested Copy Distribution (Line 16f) and Requested/Paid Electronic Copies: 1,219,084
 - d. Percent Paid and/or Requested Circulation (Both print & Electronic Copies): 69.07%

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- a. Requested And Paid Electronic Copies: 83,800
 - b. Total Requested and Paid Print Copies and Requested/Paid Electronic Copies (Line 16c): 841,756
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 - d. Percent Paid and/or Requested Circulation (Both print & Electronic Copies): 69.33%

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It's the summer of 1944 and a weathered U.S. sergeant is walking in Rome only days after the Allied Liberation. He's only weeks away from returning home. He finds an interesting timepiece in a store and he decides to splurge a little on this memento. He loved the way it felt in his hand, and the complex movement inside the case intrigued him. He really liked the hunter's back that opened to a secret compartment. He thought that he could squeeze a picture of his wife and new daughter in the case back. Besides the Purple Heart and the Bronze Star, my father cherished this watch because it was a reminder of the best part of the war for any soldier—the homecoming.



The hunter's back

The Ritorno watch back opens to reveal a special compartment for a keepsake picture or can be engraved.

He nicknamed the watch *Ritorno* for homecoming, and the rare heirloom is now valued at \$42,000 according to *The Complete Guide to Watches*. But to our family, it is just

a reminder that nothing is more beautiful than the smile of a healthy returning GI.

We wanted to bring this little piece of personal history back to life in a faithful reproduction of the original design. We've used a 27-jeweled movement reminiscent of the best watches of the 1940s and we built this watch

with \$26 million worth of Swiss built precision machinery. We then test it for 15 days on Swiss made calibrators to ensure accuracy to only seconds a day. The movement displays the day and date on the antique satin finished face and the sweep second hand lets any watch expert know that it has a fine automatic movement, not a mass-produced quartz movement. If you enjoy the rare, the classic, and the museum quality, we have a limited number of *Ritornos* available. If you are not completely satisfied, simply return it within 30 days for a full refund of the purchase price.

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New AMERICAN SUCCESS Stories



BRENT BUSHNELL
CEO

ERIC GRADMAN
CO-FOUNDER

TWO BIT CIRCUS

CHRYSLER IS PROUD TO CELEBRATE INDIVIDUALS WHO EMBODY THE NEW SPIRIT OF AMERICAN SUCCESS

If the titles CEO/Roustabout and Co-Founder/Mad Inventor are any indication, Brent Bushnell (35) and Eric Gradman (33) are making up the rules as they go. Since Two Bit Circus was founded in January 2012, the Los Angeles-based events/entertainment/education company has quickly become the go-to for big brands looking for over-the-top interactive experiences. "We're a high-tech circus. This place is filled with performers, inventors, and builders, and we're working at a fast pace with maximum creativity to reimagine entertainment with technology," says Gradman.

ON STARTING OUT: Bushnell and Gradman began collaborating on interactive art six years ago. "Eric was building robots for the military and I was building video games," says Bushnell. "We wanted something else to do nights and weekends, so we started tinkering with technology for fun, and taking our creations to public events. People loved the stuff, and one day Microsoft called and asked us to do one of their parties. We realized there might be a business."

"Better to fail fast than waste any valuable brain cycles thinking about a project that's no damn good." – Eric Gradman

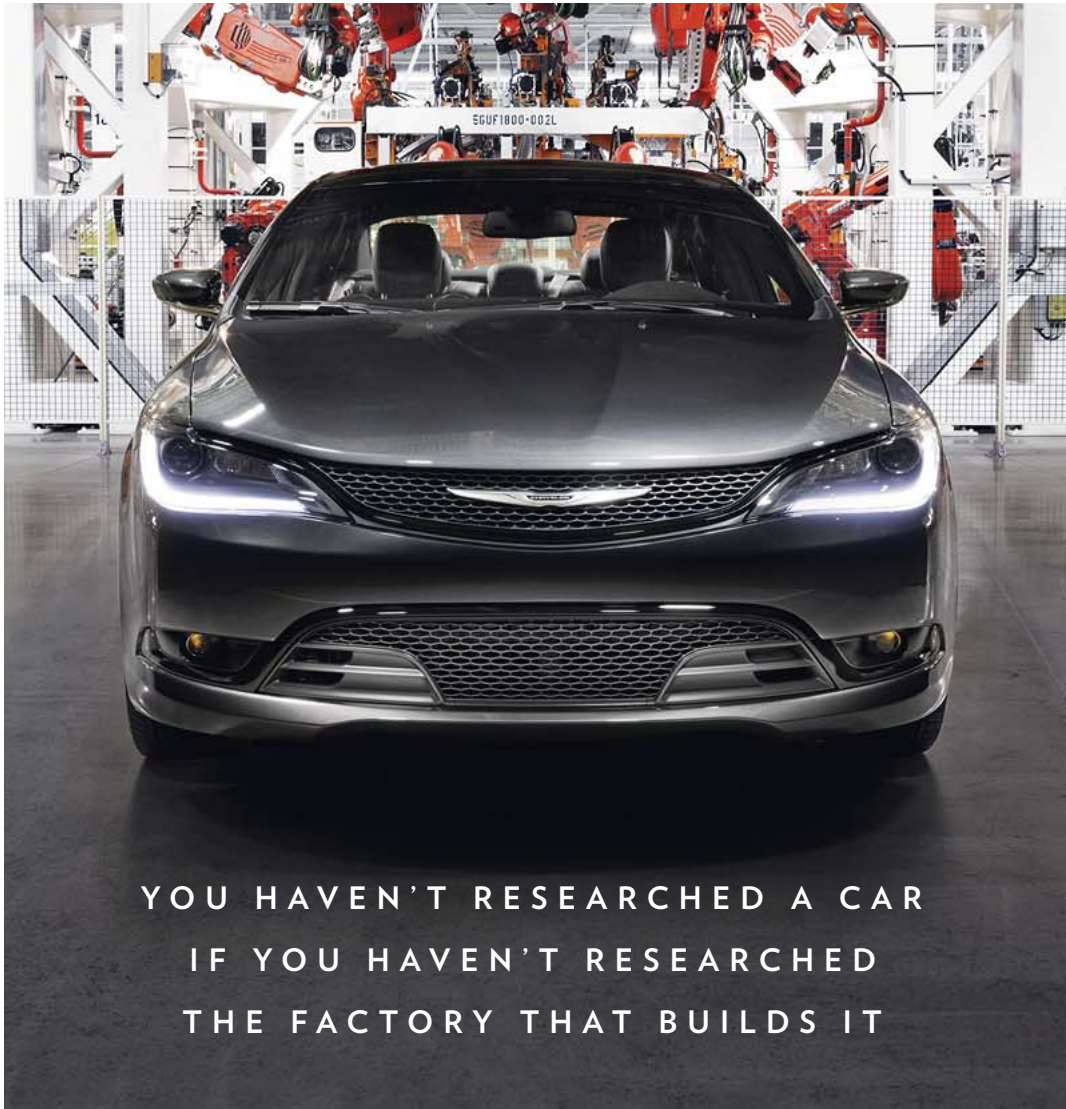
NEXT STEP: GIVING BACK: The two energetic, creative geniuses soon realized they had a great opportunity: to show kids that science and technology can be cool. This fall, they will hold their first STEAM Carnival, a festival that includes fun, inspiration, and teaching opportunities for thousands of students. "Everyone talks about the importance of STEM [Science, Technology, Engineering, and Mathematics] education—but we added the "A" for Arts, to show kids that anyone can do this, and it's about creativity."

ON SUCCESS: Two Bit Circus now employs 30 people, occupies a vast warehouse/workshop in L.A., and is able to fund its educational philanthropy projects with its profitable events business. "We've built a magical environment here," says Gradman. "Coming to work every day is a joy. Brent and I have always said that when we make a billion dollars, the only thing that'll change is that we'll buy a bigger shop with better tools."



layar

Visit PopularMechanics.com/Chrysler200 or scan this page with the LAYAR app to see a video of Bushnell and Gradman, and explore more inspirational stories.



YOU HAVEN'T RESEARCHED A CAR
IF YOU HAVEN'T RESEARCHED
THE FACTORY THAT BUILDS IT



Bronze-stitched leather seats, nine-speed transmission and a 295-horsepower V6 engine. These features of the All-New Chrysler 200 can all be seen in the showroom, but there's a whole world of features you've never heard of that can only be seen in the All-New factory that builds it.

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THE ALL-NEW CHRYSLER 200



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"We've made a long, deep investment in combating infectious diseases like Ebola," Prabhakar says. "Can we outpace it? Can we build firebreaks to keep it from spreading?"

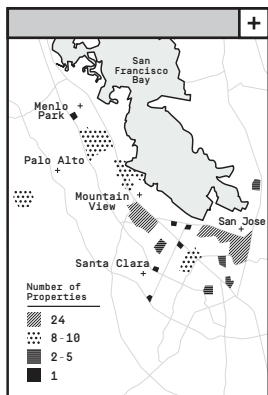


NAME Arati Prabhakar, 55
LOCATION Washington, D.C.
TITLE Director, DARPA

When Prabhakar took the reins of the military's advanced-technology research arm in 2012, she elevated the life sciences to a core position: The newly created Biological Technologies Office is charged with poaching ideas from nature and applying them to defense technology, whether that's building human-machine interfaces or engineering new microorganisms that produce materials with novel properties. DARPA researchers have already made headway on a project called Restoring Active Memory, which aims to develop implant-

able devices to heal traumatic brain injuries in service members. "And we've made a long, deep investment in combating infectious diseases like Ebola," she says. "Can we outpace it? Can we build firebreaks to keep it from spreading?" Under her watch, immune transfer—passing one person's antibodies to another—might become reliable, as may other radical approaches to instantly ramping up the body's immune responses. Prabhakar earned a doctorate in applied physics from Caltech and spent a decade in Silicon Valley venture capital, targeting IT startups and green technology. Her experience taught her the value of being nimble and nonbureaucratic, which could speed the transition of new technologies from DARPA research to the commercial and military sectors. Which, in fact, is the agency's goal. "There's our public piece and the private piece," she says. Each gets plenty done on its own—but together, she says, they can take things to new levels. — E.S.

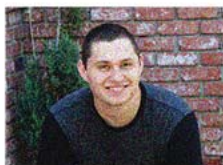
A snapshot of Arrillaga's Silicon Valley turf.*



NAME John Arrillaga Sr., 77
LOCATION Palo Alto, California
TITLE Real estate mogul

IN THE 1960s Hewlett Packard was already a mainstay in Palo Alto, California, and Stanford was doing federally funded electronics research—but no one had yet coined the term Silicon Valley. Arrillaga played a hunch and started buying fruit orchards between San Francisco and San Jose, which he and a business partner transformed into 12 million square feet of office space. Now? He's the reclusive billionaire who controls the property on which Intel, HP, Apple, and Google, among others, create technology that changes the world. — D.A.

* (He owns most of these with business partner Richard Peery.)



NAME Mark Gurman, 20
LOCATION University of Michigan
TITLE Apple blogger

THE WORLD FIRST LEARNED about the iPad in 2009, thanks to a high school sophomore who noticed that Apple had registered the domain name islate.com, which suggested a tablet computer might be imminent. Since then Gurman has nailed scoop after scoop for 9to5mac.com, including the iPhone 4S design, the advent of Siri, and Apple's foray into health tracking. His longer pieces (like a series about the workings of Apple's PR department) display an uncanny level of insight. "I'm not part of their inner circle of publications with access," he says. "If I ever get to that point, it would be time to give up." We would all lose out if the top reporter of the world's most obsessively secretive company became a cheerleader. — B.G.



NAME Cyril Ebersweiler, 35
LOCATION San Francisco and Shenzhen, China
TITLE Cofounder, HAXLR8R

THE MOTIVATION BEHIND HAXLR8R (pronounced hack-celerator) is to give promising startups a solid shot to thrive. Twice a year Ebersweiler's company selects 10 of them for a 111-day accelerator program. HAXLR8R flies them to Shenzhen to be near China's supply chains and factories and to learn about packaging, materials sourcing, and other essentials. Then startups pitch Bay Area investors. Over the past four years HAXLR8R has launched about 50 companies making original products, including Spark, builder of a platform that lets you add Wi-Fi to a piece of hardware. (In exchange, it gets a 6 to 9 percent stake in the company.) "Building hardware startups is difficult," Ebersweiler says. "I hope HAXLR8R will make them think: Now it's possible." Ninety percent of startups fail, by one estimate, but only one of HAXLR8R's firms has fizzled so far. — D.A.

"The cost of coordinating groups of people with common interests is orders of magnitude less than a decade ago. You can see how apps connect people to people, not just people to government."



NAME Jennifer Pahlka, 45
LOCATION Oakland, California
TITLE Founder and executive director, Code for America

A TOOL IN ATLANTA that allows drivers to manage their traffic tickets and court dates by text message. A program in Long Beach, California, that tracks the use—and overuse—of emergency medical services. These are two of the initiatives aimed at using technology to grease the creaky wheels of government that arose from Pahlka's 5-year-old nonprofit, Code for America, which awards fellowships to developers who solve longtime civic problems and reengage citizens. The overarching goal is to "make bureaucracy sexy," says Pahlka, who majored in American studies at Yale and who has a background in nonprofits and organizing conferences. Code for America, sometimes called the Peace Corps for geeks, is already making cities work better. A woman in Boston recently reported a possum in her trash can through the city's Citizens Connect app, hoping for an animal-control worker to come and remove it. Instead, a neighbor saw the request and turned over the can, letting the possum walk away. One citizen helped another in that case, but government connected them. "When you change these small but important experiences by building an interface that's effective and easy to use, it shifts how people perceive government," Pahlka says. "That goes a long way toward building trust." CFA's system-busting hacks were impressive enough that in 2013 the Obama administration named Pahlka as its new deputy chief technology officer for government innovation; during her yearlong tenure—she took a leave from CFA—she spearheaded the creation of the U.S. Digital Service, a team charged with sprucing up the government's digital infrastructure. With Pahlka's technology-based prodding, maybe healthcare.gov never happens again. — E.S.



NAME Monika Bickert, 38
LOCATION Menlo Park, California
TITLE Head of global policy management, Facebook

Last summer Bickert defended Facebook's infamous emotion-manipulation study, calling it part of a larger body of research that could potentially benefit everyone, working as Facebook does with various social scientists. A former federal criminal prosecutor and currently Facebook's top content officer, Bickert and her team enforce the website's terms of service—a challenging task for a social network comprising 1.3 billion people whose values are wildly divergent (a bikini photo will be received differently in Brazil than in, say, Dubai). Bickert is responsible for deciding what remains on Facebook, and what's taken down. — D.A.

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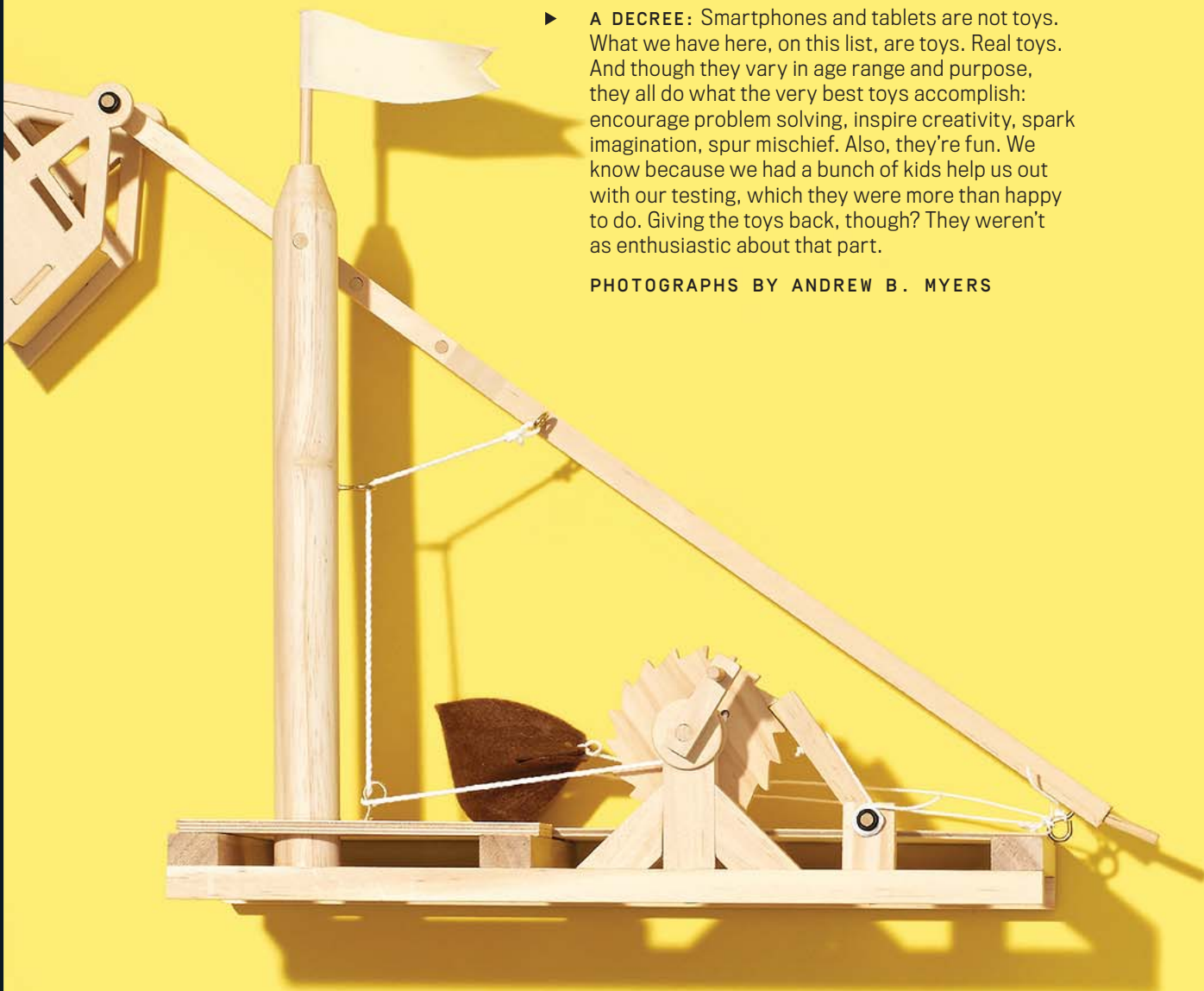


Progressive Casualty Ins. Co. & affiliates. Discounts not available in all states.

The 100% Wholesome Holiday Toy Guide

- **A DECREE:** Smartphones and tablets are not toys. What we have here, on this list, are toys. Real toys. And though they vary in age range and purpose, they all do what the very best toys accomplish: encourage problem solving, inspire creativity, spark imagination, spur mischief. Also, they're fun. We know because we had a bunch of kids help us out with our testing, which they were more than happy to do. Giving the toys back, though? They weren't as enthusiastic about that part.

PHOTOGRAPHS BY ANDREW B. MYERS



PROMOTES
ENGINEERING
SKILLS

- **Da Vinci's Trebuchet • Age 8+ / \$30 •** Make sure to glue the gear on in the right direction—that's step one, by the way—and an hour later you end up with a working medieval war machine inspired by Leonardo da Vinci's sketches. With the proper counterweight, it'll launch a barrage of marbles right into an approaching phalanx of green army men.

2014 Toy Guide



"The world is limitless—that ought to be the perspective of a child."

PATRICK CALELLO, FOUNDER, AUTOMOBLOX

5 Carson AdventurePak

"Now that we have all of our tools, let's go on a dinosaur hunt."

JAMES CONNORS, 5

4 Parrot MiniDrone Jumping Sumo

3 Automoblox Emergency Response Line

PROMOTES
CREATIVITY

1 Age 8+ / \$34 • Handcrafted from perfectly forked Nicaraguan *Mora* tree branches, Hella's slingshots are sturdy enough to withstand constant use, which is what they'll get.

2 Age 18 mos.+ / \$35 • The back of this remote-control truck teaches shapes, colors, and recycling basics. The front looks like a Pixar character. Our testers went nuts.

3 Age 3+ / \$45 each • Created by an industrial designer, these beautifully crafted wooden cars come apart in sections so kids can build their own custom rides.

4 Age 14+ / \$160 • The Sumo's spring-loaded rear foot lets it clear obstacles and even hop onto chairs. It's controlled with an intuitive smartphone app.

5 Age 7+ / \$35 • Real binoculars, a working compass, a bright flashlight, and a piercing whistle—everything a junior explorer needs for a proper adventure.

6 Age 5+ / \$23 • Stomping on the air-filled blast chamber fires a foam-tipped rocket 200 feet into the night sky. A green LED makes it easy to track—and find.



THE PHANTOM ROSE GOLD

'PHANTASTIC VALUE PHENOMENAL QUALITY'

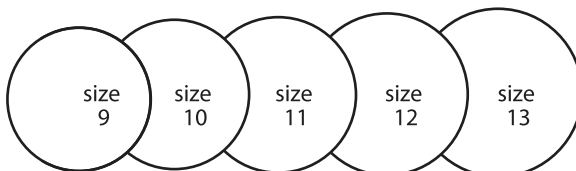
Phantom Watch \$199 Phantom Ring \$129 Set Price \$289 (Save An Extra \$39) + S&P

The Daniel Steiger Phantom Rose Gold. Engineered from premium grade 316L steel and plated in a mixture of rose gold and black IP, the words designer styling really could have been invented for this timepiece. A precision chronograph movement featuring 24 Hour, Stopwatch Seconds & Minutes sub-dials and date window are displayed on the multi-levelled face. Now available direct from the manufacturer at the astonishingly low price of \$199 - a saving of \$596

on the retail price of \$795. So how can we make an offer like this? The answer is beautifully simple. We have no middleman to pay, no retail overheads to pay and not the usual mark-up to make, which on luxury items can be enormous. To accompany the Phantom, we have introduced the Phantom ring. With layers of rose gold plated steel and an impressive row set with our flawless Diamond gems, that can cut glass like a mined Diamond.

RING SIZE CHART

Place one of your own rings on top of one of the circles to the right. Your ring size is the circle that matches the diameter of the inside of your ring. If your ring falls between sizes, order the next larger size.



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1 Waba Fun Kinetic Sand



7 Groovy Lab in a Box



6 LittleBits Space Kit

5 Design & Drill
Socket to Me

"I have my own tools!"

JAKE PARSLAW, 3½

"I felt like an architect designing fancy buildings, restaurants, and carnival rides."

JOHN D'AGOSTINO, 7



2 Magformers Designer Set

PROMOTES
SCIENTIFIC
INQUIRY

3 Science Tech Two-Way
Bug Viewer

"Cool! Tiernan, look what happens when you wave your hand over here!"

AIDAN CAIN, 13

"You learn best when you are actively making real things in the real world."

AYAH BDEIR, FOUNDER, LITTLEBITS



4 AquaFarm Fish Tank

1 Age 3+ / \$15 • A physics lesson: Kinetic sand is a non-Newtonian material, which means the mixture of 98 percent sand and 2 percent polymer takes on different properties depending how much pressure you apply. In short, it's really weird and really fun.

2 Age 6+ / \$90 • Inside the edges of each geometric shape are powerful magnets that snap the pieces together for a whole new type of building experience. Advanced sets come with gears and people, while the tough plastic keeps the magnets secure.

3 Age 5+ / \$10 • Ever looked at a potato bug up close? Like a translucent armadillo,

that thing. With a magnification of 6x from above and 4x from the side, this viewer gives kids a new appreciation for nature. Also, it's well-ventilated, so no casualties.

4 Age 12+ / \$60 • The fish provide nutrients for the plants (just think about it), while the roots of the plants up top keep the water clean. The kids feed the fish, and, if you grow herbs in the pots, everyone eats the plants. It's a tidy little system.

5 Age 4+ / \$22 • There's just something about tightening a bolt—even if it is orange and plastic. Kids learn how to handle a working socket wrench while "building" a

robot, car, ship, and rocket. The best part? The wrench makes actual ratchet noises.

6 Age 8+ / \$189 • LittleBits are electronic modules that connect via magnets to create pretty much anything you can conceive of. The new space kit, with projects designed by NASA scientists, has kids making their own Mars rover, among other projects.

7 Age 8+ / \$36 • Every Groovy box is filled with projects that promote STEM (science, technology, engineering, and math) skills. Available individually or with a monthly subscription, each themed box includes everything kids need to, say, build a roller coaster.



8 Tegu Blocks 42-Piece Set



"I made a car!"

CELIA MANN, 6

"Is this available in stores yet?
Because I definitely want to buy this."

LUCY MANN, 7

9 GoldieBlox and the Movie Machine



13 Roominate Chateau



"We wanted this to be a tool that encourages creativity and gets girls exploring and engineering."

ALICE BROOKS,
COFOUNDER, ROOMINATE

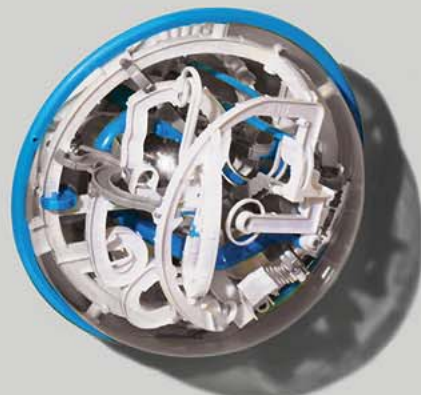
"I had to think a lot about what I was doing. When I play with my dolls, I don't have to think about much. This was really fun."

BELLA CROSS, 7



12 Learning Resources
Snap-n-Learn
Number Bugs

PROMOTES
PROBLEM
SOLVING



10 Perplexus Epic



11 DigiBirds

8 Age 1+ / \$110 • Embedded magnets give Tegu blocks an edge over the standard wooden cube, and the responsibly harvested huesito wood makes them more beautiful.

9 Age 6+ / \$30 • GoldieBlox pairs books with kits to introduce girls to engineering fundamentals. The Movie Machine set, which also teaches animation, was a tester favorite.

10 Age 8+ / \$25 • Guiding a small marble through this spherical maze's 125 obstacles requires intense focus—and patience. Lots and lots of patience.

11 Age 5+ / \$15 each • Whistle to or blow on a DigiBird and it sings one of 20 distinct tunes, moving its head and beak in time. Multiple birds harmonize to form a chorus.

12 Age 2+ / \$20 • Each differently numbered and colored bug breaks into three interchangeable pieces. Great for teaching basics. Also, apparently, for chewing on.

13 Age 6+ / \$50 • Roominate turns girls into dollhouse contractors, designing and building their own furniture and rooms, complete with wiring for lights and motors.

1 PowerUp 3.0

2 Estes Manta II Rocket

3 KOTA
Nieuport 17
LongboardPROMOTES
COORDINATION
▷

"You don't have to try that hard to get it going, and it's even fun to run into things."

VAUGHN HOWARD, 10

4
EzyRoller
Classic5
Snap Circuits
Motion Set6
K'Nex 52-Model
Building Set7 Land of Nod Jetaire
Camper Play Tent

"I imagined I was camping. At night. In the forest. I felt like I could hear crickets and frogs."

BENNETT D'AGOSTINO, 5

1 Age 14+ / \$50 • Clip a Bluetooth receiver connected to a propeller onto the nose of a paper airplane to control its flight via a free smartphone app.

2 Age 10+ / \$35 • Nothing will ever replace the pleasure of hitting a launch switch and watching something you made race upward and out of sight. Plus, a glider!

3 Age 10+ / \$314 • Designed by former military pilots, KOTA (Knights of the Air) boards

are great for deep carving. The flexible yet strong deck is made of seven-ply hard rock maple from Wisconsin.

4 Age 4+ / \$99 • How it works: Kids swivel the front foot bar to create momentum. The hand brake keeps them from flying into a ditch. And the steel frame means it can take a beating.

5 Age 8+ / \$80 • Just snap electrical components onto a plastic board to create different

circuits and a variety of moving contraptions. The Motion set has more than 150 air-blowing, light-changing, fan-spinning projects.

6 Age 7+ / \$35 • When it debuted in 1992, this plastic rod-and-connector construction system was unlike anything else. Still is.

7 Age 3+ / \$249 • A bit more than 6 feet long, the underlying metal structure is sturdy and easy to assemble. The cover is hand-stitched cotton canvas, so you know it will last.

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The Classics

"If you attended one of our brainstorming sessions, you'd see how all of us regress pretty quickly to being childlike in our behavior. We tap right into that inner 3- or 4-year-old."

DAN MULDOON, FISHER-PRICE TOY DESIGNER



**Lincoln Logs
Collector's Edition
Homestead**
Age 3+ / \$100



Lego Creative Tower
Age 4+ / \$90



**Fisher-Price
Rock-a-Stack**
Age 6 mos.+ / \$7



**Hasbro Barrel of
Monkeys**
Age 3+ / \$5



**Playskool
Mr. Potato Head**
Age 2+ / \$8



Play-Doh
Age 2+ / \$15



**Fisher-Price
Little People
Fun Sounds Farm**
Age 1+ / \$40



Tupperware Shape-O
Age 6 mos.+ / \$29



Little Tikes Cozy Coupe
Age 18 mos.+ / \$55

Five Great Board Games



ROBOT TURTLES
Age 4+ / \$25

Turtles, jewels, bugs, ice walls, lasers . . . and programming. It's never too early to learn how to code.



PANDEMIC
Age 8+ / \$40

Save humanity by working with other players. An uncommon but surprisingly fun game concept.



KING OF TOKYO
Age 8+ / \$40

Magic: The Gathering meets Godzilla & Co. Or, for those unfamiliar: It's a card-and-dice game with monsters.



SETTLERS OF CATAN
Age 10+ / \$42

Barter and compete for resources to build your own settlement. So, Western Civ class in 19 hexagonal tiles.



POWER GRID
Age 13+ / \$45

Should you improve your own grid if it benefits other players? Practically an exposé of public utilities.

INSIDER'S TAKE ON THE CHEVROLET TRAVERSE

#3 IN A SERIES

Alma Schneider
Kitchen Therapist

NEW DIRECTIONS IN FAMILY TIME

STEERING OTHERS TOWARD KITCHEN CONFIDENCE

LICENSED CLINICAL SOCIAL WORKER **ALMA SCHNEIDER** founded Take Back the Kitchen to treat people's kitchen phobias. Breaking through psychological barriers like gender-role complex (thinking cooking's not cerebral enough), Alma helps people be everything they want to be at the stove. But is the **CHEVROLET TRAVERSE** everything she wants in a midsize SUV?

"Clients who were kept out of the kitchen or criticized early on say, 'Forget it. It's not for me.'"

Cooking's not about making fancy food, says Alma. "It's about serving people and eating with people."

—the— NEWS

FOR POPULAR MECHANICS READERS

We asked *Car and Driver* enthusiast Peter Ha for some insider advice. And a test-drive quickly convinced him that the **Chevrolet TRAVERSE** was the complete family-friendly package Alma was looking for.

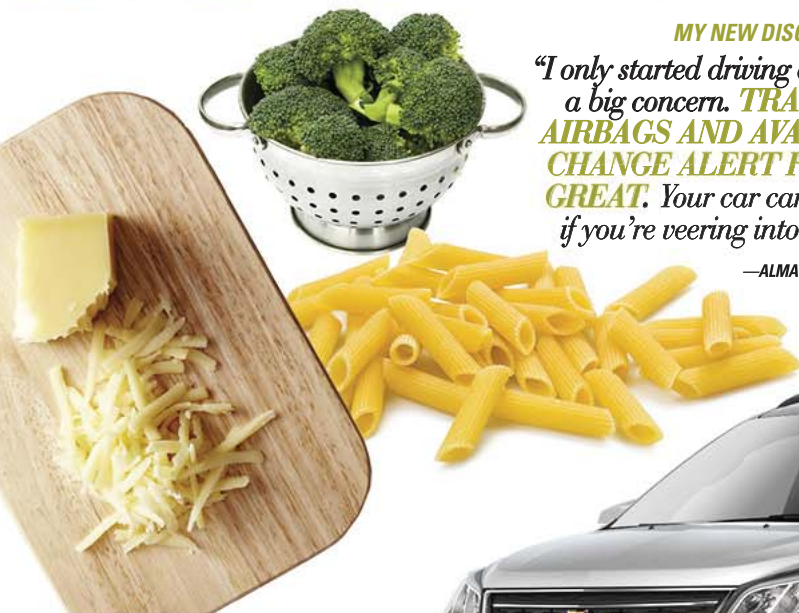
> A refined midsize SUV with seating for up to 8 and class-leading cargo room.*

MY NEW DISCOVERY

*"I only started driving at 34—so safety's a big concern. **TRAVERSE'S SIX AIRBAGS AND AVAILABLE LANE CHANGE ALERT FEATURE ARE GREAT.** Your car can help you notice if you're veering into the next lane."*

—ALMA

*116.3 cu. ft. of maximum cargo room



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¹ Government 5-Star Safety Ratings are part of the National Highway Traffic Safety Administration's (NHTSA's) New Car Assessment Program (www.SaferCar.gov). ² Always use safety belts and child restraints. Children are safer when properly secured in a rear seat in the appropriate child restraint. See the Owner's Manual for more information.

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CARS

UP AHEAD:

- 78 Button of the year.
- 80 Hyundai's excellent luxury sedan. Yep, Hyundai.
- 82 The most powerful car Detroit has ever built.

The Popular Mechanics Car Awards*

Because not all vehicles are created equal.

2015
Car of the
Year



Volkswagen Golf GTI

If you're trying to locate the point of diminishing returns, here it is: \$25,215. That's the starting price for a 2015 Volkswagen GTI. And while you can spend far more on a car, nothing else can approach the GTI's singular blend of performance, quality, and value. This is the rare vehicle that transcends demographic boundaries—it would look equally at home parked outside a dorm or at a manse in the Hamptons.

Volkswagen redesigns the GTI the same way Porsche does the 911, choosing meaningful evolutionary improvements rather than drastic overhauls. So the new ▶

PRICE: \$25,215

MPG (CITY/HWY): 25/34

*FORMERLY KNOWN AS THE AUTOMOTIVE EXCELLENCE AWARDS. TOO MANY SYLLABLES.



CARS

GTI is a little bit crisper looking, a little more powerful, a little lighter than the last one. But the essential recipe is unchanged: a sweet, punchy, turbocharged four-cylinder under the hood; a playful front-wheel-drive chassis; and an improbably roomy interior that's rocking plaid seats (you can also get leather, but why would you?). A six-speed manual is standard, Volkswagen's excellent DSG dual-clutch transmission optional.

Compared with a basic Golf, the GTI's suspension is lower and stiffer, the steering quicker. Red brake calipers and 18-inch wheels are the main exterior telltales. In lieu of the standard 1.8-liter engine, a 2.0-liter four-cylinder makes 210 hp and 258 lb-ft of torque. That latter number is 51 lb-ft more than the previous GTI's, and you can feel it when you're tearing down a curvy back road and realize you don't need to downshift to power out of a corner. The car just goes where you aim it, and quickly. It really feels like something that comes from the same gene pool as the Bugatti Veyron—which, of course, it does.

Within the next month or two, a new Performance Package will add 10 hp, larger brakes, and a limited-slip differential that will cut 8 seconds off the GTI's Nürburgring lap time. That's great, but perhaps beside the point for a car that is, right out of the box, the total package.

The GTI feels like a car that comes from the same gene pool as the Bugatti Veyron—which, of course, it does.



OTHER CARS WE LIKED THIS YEAR:
Ram 2500 Power Wagon As a rock-crawling, heavy-duty truck, the Power Wagon has no competition. But Ram upgraded it anyway, with a coil-spring rear suspension, new gearing, and a 6.4-liter Hemi replacing the 5.7.
BMW M235i The M235i avoids the bloat trend with a length that matches the beloved 1990s E36 3 Series'. It's intimate, wild, and blazing fast.

BOGUS TREND:
Synthetic Engine Sounds
 BMW does it. Volkswagen does it. Now so does Ford with the 2015 Mustang EcoBoost, which uses audio to augment its engine's soundtrack. Want to hear what your car really sounds like? Pull the fuse.



REINCARNATION OF THE YEAR

2015 Chevrolet SS

WHEN GENERAL MOTORS killed Pontiac, the saddest casualty was the G8 GXP, a ferocious rear-drive sedan borrowed from the company's Holden division in Australia. Well, the G8 got a second chance, reincarnated as a Chevy and bringing the same 415-hp V-8, drift-happy chassis, and available manual transmission that we loved the first time around. G8, SS—whatever you call it, we're glad it's back.

PRICE: \$45,770

MPG (CITY/HWY): 14/21

BEST BUTTON

2015 Jaguar F-Type V-8 S Active Sport Exhaust

ON THE F-TYPE'S CENTER console is a button emblazoned with what looks like a pair of eyeglasses. It should have an image of earplugs instead. Pushing it tells the coupe's exhaust system to bypass the muffler, unleashing a glorious fusillade of pops and crackles that sounds as if Molotov cocktails were pouring out the exhaust manifolds.

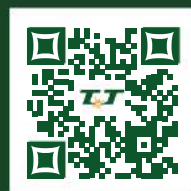
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CARS

To combat drowsiness, the Genesis's ventilation system automatically circulates fresh air if a sensor detects that CO₂ levels are too high.



PRICE: \$38,950

MPG (CITY/HWY): 18/29

Hyundai's Ascension

2015 Hyundai Genesis

THE FIRST-GENERATION GENESIS, Hyundai's attempt at entering the luxury market, put up the right numbers—horsepower, size, price—but fell apart when it came to nuances such as ride and interior quality. Which is why the follow-up effort, the 2015 Genesis, ought to have the Germans and everyone else worried. This time around, Hyundai knows that intangibles make all the difference in the realm of luxury sedans, where all the cars are good.

Hyundai recruited Lotus to help tune the suspension, which is thoroughly redesigned and stiffer than before. The steering feels good. The sleek interior cribs more than a couple pages from Audi's playbook, deploying aluminum and matte-finish wood trim to fine effect. Underscoring Hyundai's dawning appreciation for refined excellence over gaudy stats, the standard 3.8-liter V-6 actually sacrifices horsepower—311, down from 333—in exchange for

more low-rpm torque, improving real-world performance. It's a silky thing, this V-6, but there's also a 420-hp V-8 available for those seeking the full dread-nought experience.

The styling of the new Genesis looks vaguely European, but it's original enough that people walk up and ask what kind of car it is. Reply Genesis and confusion might ensue, as most Americans will think of the Bible first, Phil Collins second, and Hyundai a very distant third. That lack of cachet, of bankable brand snobbery, is why this car is such a bargain—a totally loaded V-6 costs less than the cheapest Mercedes E-Class.

The Genesis, right now, is in a sweet spot. Hyundai has figured out how to build a legit luxury sedan but hasn't been doing it long enough to charge a premium. Hyundai now is like Lexus in the early '90s: striving hard and still on the way up.

THE INTERIOR OF THE FUTURE

2015 BMW i3

THE i3 INCLUDES A LOT OF groundbreaking technology, but it'll be best remembered for its stunning interior. The hybrid's cabin looks like a designer's fantasy sketch: The dashboard's thick sweep of eucalyptus pours into the freestanding steering column, and the sleek seats are available with recycled upholstery. If this is the future, it looks great.

PRICE: \$42,275

MPGE (CITY/HWY): 137/111

CHOICEST BASE MODEL

2015 Mini Cooper

THE BASE COOPER HAS always trailed far behind the Cooper S in terms of sheer fun. Not anymore. The new standard Cooper includes turbo power—in this case, a 134-hp 1.5-liter three-cylinder. Now the base Mini is good for 130 mph, which is just fantastic.



PRICE: \$21,550

MPG (CITY/HWY): 26/35

PRICE: \$30,095

MPG (CITY/HWY): 50/45



The 50-MPG Family Car

2015 Honda Accord Hybrid

THE BEAUTY OF the Accord Hybrid is that it scores real-deal 50-mpg fuel economy without so much as mildly inconveniencing its driver. With cutting-edge technology hidden inside one of the most eminently likeable sedans you can buy, the Honda delivers radical efficiency, day in, day out. The Accord's driving experience is a little

unconventional because the Honda's architecture has more in common with an electric car than with, say, a Camry Hybrid. While traditional hybrids augment a gas engine with a small electric motor, the Accord mostly relies on a robust, 166-hp electric motor. The car's 2.0-liter four-cylinder is there mainly to generate electric-

ity, revving up as needed and going dormant for surprisingly long distances as the car runs off its lithium-ion battery (there's also a plug-in version that uses a bigger battery). Behind the wheel, you don't much notice the energy transfer happening. It's just an Accord—an Accord with the ability to go 750 miles between fill-ups.

PRICE: \$34,595

MPG (CITY/HWY): 14/19

The Triumph of the Van

2015 Ford Transit

YOU DON'T NEED TO BE A ROADIE or a *19 Kids & Counting* cast member to appreciate the appeal of the new Ford Transit. Replacing the ancient E-Series, the unibody Transit offers unbeatable power and capacity for the money. An eight-passenger EcoBoost XLT goes for about \$36,000—minivan money for Euro-style capability. The smallest Transit is slightly shorter than a Chevy Suburban yet offers more than twice the cargo room. As for medium- and high-roof versions, you could park a Smart car inside.

The Transit offers naturally aspirated V-6 and diesel-power options, but the hot ticket is the 310-hp EcoBoost model. With rear-wheel drive and 400 lb-ft of torque, the big-box Ford is an unexpected riot to drive, its twin turbochargers whistling and sighing from beneath that stubby hood. Another plus: Fuel economy improves 46 percent over the outgoing model's 6.8-liter V-10.

While stripped-down windowless cargo versions will surely find an audience with tradesmen, it's the turbocharged passenger Transit that's most intriguing: It can tow 7,300 pounds, haul 3,550 pounds, and seat up to 10 people—all while delivering genuine fun behind the wheel. In the early '80s, the advent of the minivan helped kill the full-size American van as a family vehicle. Now, more than 30 years later, the Ford Transit just might bring it back.



TRICK OF THE YEAR: Honda Fit Lounge Chair

Move the front passenger seat forward and remove the headrest. Recline the rear seatback and lower the front seatback, which goes almost flat. Now you've got a chaise longue.

ENGINE OF THE YEAR

Volvo 302-HP 2-Liter Drive-E

VOLVO'S TOP DRIVE-E engine combines the instant response of a supercharger with the top-end power of a big turbo, resulting in a four-cylinder that produces V-6-level horsepower with no lag. Step on the gas and a supercharger gets to work immediately, imperceptibly handing off to the turbo as revs build. It's smooth, it works, and it's the only dual-charged engine in the U.S.



BEST USE OF A DASH CAM

Corvette Performance Data Recorder

A NEW OPTION ON 2015 Corvettes, PDR combines a 720p camera, an interior microphone, and a dedicated GPS-based telemetry system. Performance data is then overlaid on a corresponding video on the dash screen so you can review your heroics (or, more likely, follies). PDR: It's cool, it's fun, it's admissible evidence!

CARS



PRICE: \$60,990

MPG (CITY/HWY): 13/22

Best Muscle Car

2015 Dodge Challenger SRT Hellcat

BESIDES OWNING THE GREATEST MODEL NAME of the past decade, the SRT Hellcat packs the most powerful engine ever shoehorned under an American hood: a supercharged 6.2-liter V-8 that spits out 707 hp and inhales through a hole where one of the headlights should be. This is not a track car in the manner of a Camaro Z/28 or the Boss Mustangs—the Hellcat doesn't particularly like corners, or bumps, or people. It's an ornery bastard built for the sole purpose of taking names at the drag strip, where low-11-second quarter-mile times put it close to the Ferraris and McLarens of the world. These days we expect even superfast cars to remain approachable, sanitized for public consumption, but the Hellcat is a throwback to the days when high performance demanded commensurately high skill on the part of the driver. As such, it comes with two keys—a black one that locks it down to about 500 hp, and a red one to unleash the full fury. Armed with the red key, you're ready for sub-4-second 0-to-60 runs or mile-long burnouts in this, the wildest muscle car Detroit's ever built.



Semi-Affordable Driving Experience of the Year

2015 Alfa Romeo 4C

ALFA ROMEO finally returns to the U.S. with a two-seater that's sexy, fast, and has just enough flaws to remind you it's not a Porsche: The climate-control pod juts into your right leg, the stereo looks straight off the shelf from Best Buy, and the steering follows every rut in the road. But you

won't care, because you're surrounded by a beautiful carbon-fiber tub with a turbocharger howling behind your left ear and the exhaust popping and fizzling away. The 237-hp 1.7-liter four-cylinder isn't overwhelmingly powerful, but the car still screams off the line. That's because it

PRICE: \$55,195

MPG (CITY/HWY): 24/34

only weighs 2,465 pounds, and the dual-clutch gearbox keeps the motor singing. On a twisty road, you think you're driving something that costs three times as much. Which is not to say the 4C is cheap, but it is a bargain for a carbon-fiber slice of midengine Italian driving nirvana.

THE DEREK JETER RETIREMENT AWARD

Toyota FJ Cruiser Ultimate Edition

THE FJ CRUISER IS done after this year, but 2,500 Ultimate Editions have it going out in style, with Heritage Blue paint, Bilstein coil-over front suspension, and TRD wheels. The FJ was an improbable vehicle for Toyota, a concept car turned reality, and we heartily hope it returns.



PRICE: \$28,565

MPG (CITY/HWY): 16/20

CLOSEST THING TO A RACE CAR
2015 Chevrolet Camaro Z/28

THE Z/28'S FRONT tires—Pirelli Trofeo Rs—are massive. The shocks come from an F1 supplier. On a track you could beat a Porsche 911 Turbo—if the surface were dry. And warm. And you had the courage of a thousand lions.

PRICE: \$75,995

MPG (CITY/HWY): 13/19

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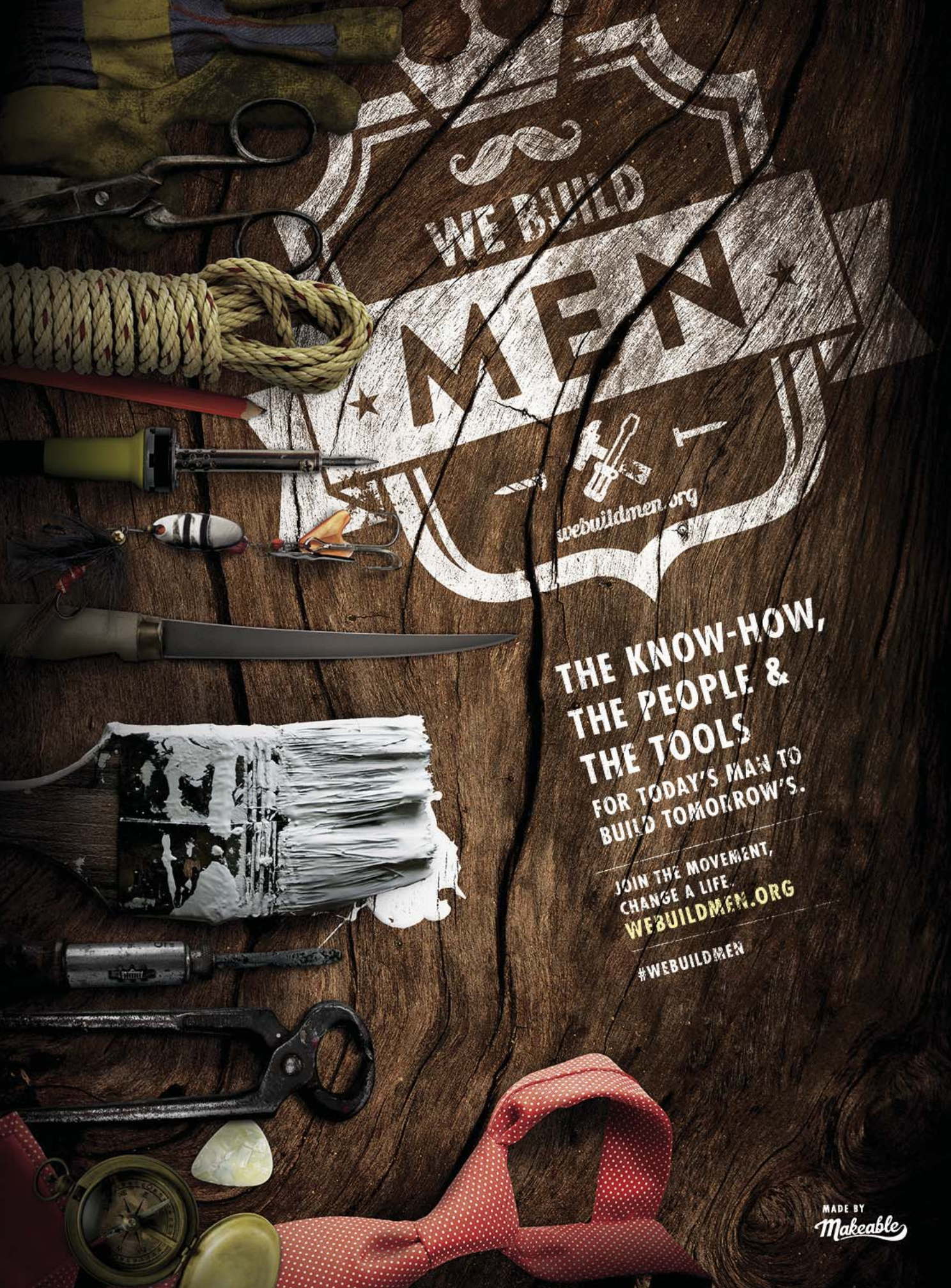
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To avoid the dreaded Gordian knot of Christmas, wrap your lights around a coffee can before storing them.

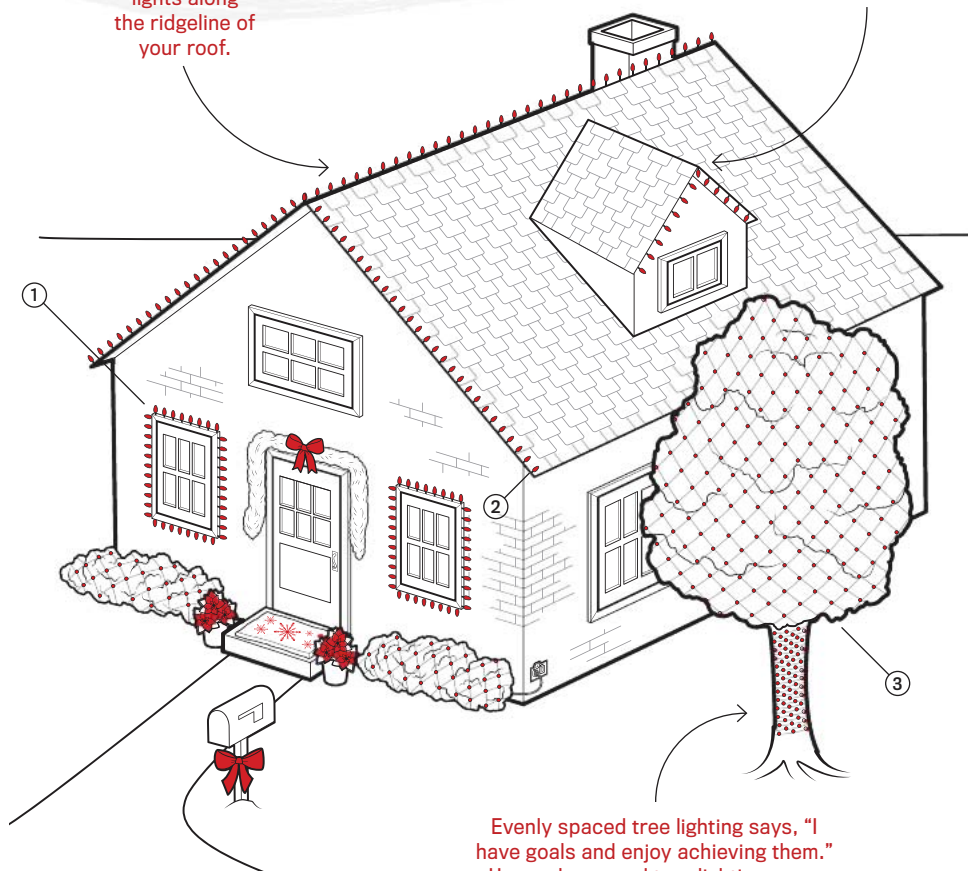
CHRISTMAS LIGHTS, ILLUMINATED

How to inspire awe in your neighbors, one tiny bulb at a time.

DESPITE NEIGHBORHOOD PEER PRESSURE, you and you alone dictate the aesthetic direction of your home's holiday display. He who wields the extension ladder in subzero temperatures earns the creative freedom to decorate his yard however he pleases. Our recommendation: Take one of the three approaches on the following pages. The first is refined; the second is, uh, festive. And the third is the very least you can do. All are guaranteed to earn you a place on the itinerary of drive-by light gawkers—without provoking anyone to take a chainsaw to your front porch.

Want to win the admiration of your entire neighborhood? Put lights along the ridgeline of your roof.

Unlike strands of old, today's lights will stay lit even if a bulb goes out, so long as the broken bulb remains in place and completes the circuit.



Evenly spaced tree lighting says, "I have goals and enjoy achieving them." Unevenly spaced tree lighting says, "Hey! Come take a look at this before I flush it!" Decorate accordingly.

TYPE 1 OF 3

THE HOLIDAY CLASSIC

For a traditional look, keep the lights white and dedicated to three spaces: along gutters or eaves, in windows, and on larger trees or bushes. Aim for symmetry. And remember: There are three varieties of white LED lights. Warm white mimics the glow of classic incandescent bulbs. Polar white gives off an icy-blue tinge. And pure white is just what it sounds like. Ideally, you want a mix. Place warm-white strands along the eaves or gutters, and offset those with polar-white lights in your greenery. The two tones play off each other well. Avoid pure-white bulbs. They can make your home look like an enormous headlight.

THE INSTRUCTIONS THAT SHOULD COME IN THE BOX

1. LIGHTS

Before you start, make a plan. Measure the locations where you will string lights. Most likely this will be along eaves or gutters and around windows. Use this plan to estimate how many strands you'll need and how long they should be. Unfortunately, there are no standard strand lengths, but there are standard-size bulbs and standard distances between bulbs on a strand. Look for C7- or C9-size bulbs spaced 6 to 8 inches apart. A longer distance between bulbs allows for more light to spread across a wider area, creating more picturesque shadows and greater warmth.

2. LAYOUT

Place the first bulb from the male end of a strand on the corner of your eave that's closest to an outlet. Now extend the line around the exterior of the house, keeping the string taut. Secure the lights with gutter clips so they don't creep up the roof. These are cheap, so buy a bunch. A discreet extension cord will connect the lights to the outlet.

A BRIEF TAXONOMY OF HOLIDAY BULBS

INCANDESCENT



Classic, filament-based bulbs that give off a warm glow.

LED



Last twice as long as incandescents. Can appear cold.

WIDE-ANGLE LED



Nubbed LEDs with concave tips that throw light.

TRANSPARENT



Colored minibulbs with visible filaments.

3. TREES

You could use net lights (see “A Brief Taxonomy of Holiday Bulbs”), but that’s kind of a cop-out. Instead, wrap regular minilights around the trunk and branches. To determine how many feet of lighting you need, divide the height of the trunk by the desired spacing between each strip of lights; about 3 inches is ideal. Then multiply that number by the trunk’s circumference. Do the same calculation for any large branches you want to wrap. First, wind the lights up the tree, leaving about 6 inches between each pass. Continue on to the branches, then wrap back down into the empty spaces. That will give you the desired 3-inch spacing. So, for a 6-foot-tall trunk with a circumference of 2 feet, divide 72 inches by 3 inches of spacing, for a total of 24. Multiply 24 by the 2-foot circumference, for 48 feet of lights.

4. ELECTRICIANS

Most blown fuses are caused by moisture getting into the connectors that attach strings of lights to each other. Sealing each connection and the loose ends of a string with duct or electrical tape will keep everything dry.

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HANGING LIGHTS



GIFTING



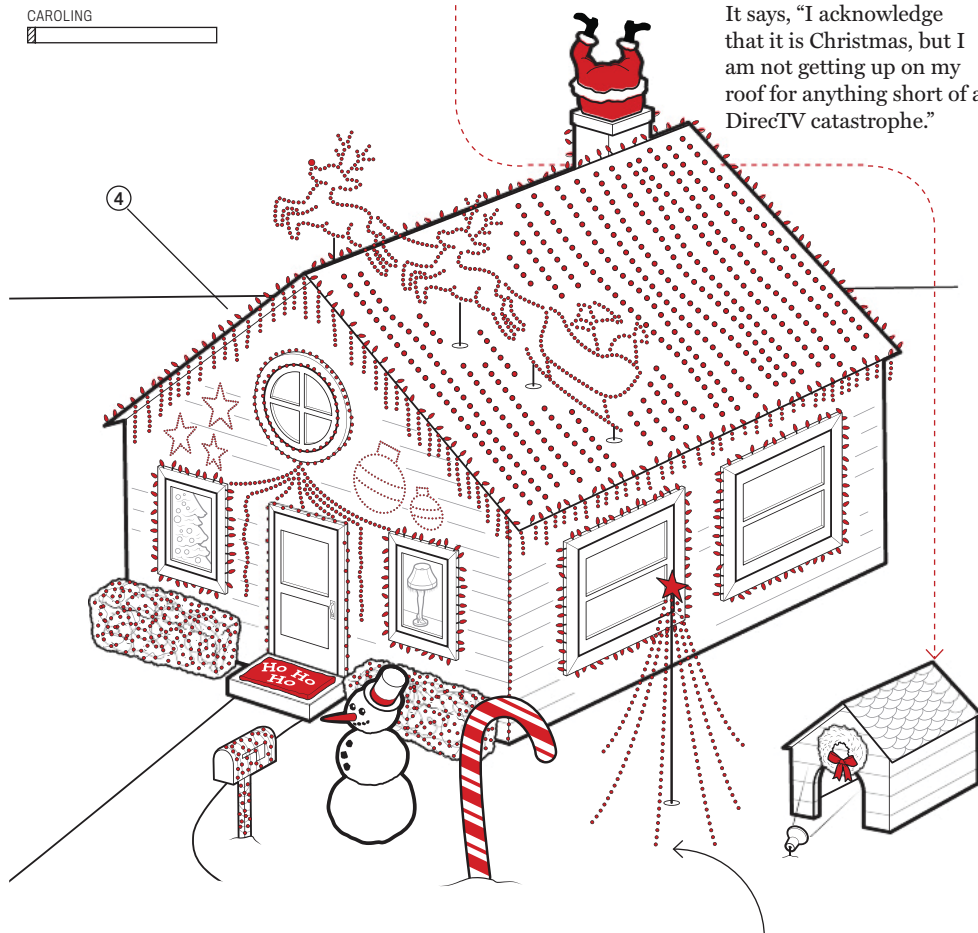
CAROLING



TYPE 3 OF 3

THE MINIMALIST

Buy a real pine wreath and put it on the door. Then stake an E17 LED warm-white bulb a couple of feet back from the door and aim it at the wreath. It says, “I acknowledge that it is Christmas, but I am not getting up on my roof for anything short of a DirecTV catastrophe.”



TYPE 2 OF 3

THE DELIGHTFUL MONSTROSITY

The difference between a stately display and a glaring pile of festivity is in the color and number of bulbs. Use a multicolored strand along the gutter; under that, string icicle lights. Vary the size between the bulbs. Bigger C9 bulbs go along the roofline and gutters; C7s are better for the perimeters of windows. You can wrap a garland in minilights. You can wrap your mailbox. You can splay net lighting over your bushes. But please, no blow-up or animatronic lawn decorations. These invite an awkward conversation with your 6-year-old after the deer on your lawn are rearranged in lewd positions by stealthy neighborhood teens.

To create a well-proportioned light tree, tape the ends of the strands to a hoop.

CERAMIC



Opaque and look as if they’ve been painted. A classic.

GLOBE



LEDs inside globe-shaped bulbs that stay cool.

NET LIGHTS



Minilights or small LEDs in a webbed circuit.

RGB LED



Programmable diodes that can display almost any color.

HOW TO DAMP-PROOF YOUR BASEMENT

A lesson I picked up from my father, who's been teaching me home projects since I was 3. **BY LYNDIE GREENWOOD**

GROWING UP, whenever there were odd jobs to be done around the house, my dad would always have me help. Once, when teaching me how to fix a leaky faucet, he showed me all the parts, and something in my head just clicked. It's not a magic trick. There's a certain way these things work, and usually there's not much to it. Ever since then I've had a certain mentality. If I can look at something for a minute, I can probably figure out how to fix it.

My dad still lives in my childhood home in Toronto. There's a concrete lane between our house and our neighbor's that runs alongside our foundation, and this fall my dad decided to stop the moisture that had been slowly coming in through it. As always, he showed me how.

TIP!

A masonry patch this small can crack if it's not kept moist. Spray down the foundation wall and sidewalk with a hose to keep them from pulling too much moisture out of the lip as it dries.

As the lip cures, either cover it with plastic or gently moisten with a watering can.

Even the slightest gap between your foundation and a concrete sidewalk can lead to basement leaks. First, clean out the dirt and weeds that may have accumulated against the foundation wall. Then use a concrete or a low-shrink grout to build a lip over the gap—about 2 inches up the wall and 2 inches onto the sidewalk, with a slope of 45 degrees. It's a simple fix, but an important one.

OUR EXPERT

The daughter of a plumbing and general-construction inspector for the city of Toronto, Lyndie Greenwood now stars in *Sleepy Hollow*, the story of Ichabod Crane, a Revolutionary War soldier summoned back to life in the present day to try to stop the also-resurrected Headless Horseman and the impending apocalypse he brought with him. It airs Mondays at 9 p.m. on Fox.

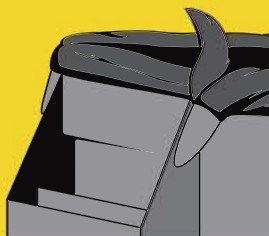


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SO YOU WANNA MAKE AN APP

Who hasn't had a great idea for a smartphone tool—but not the slightest idea where to begin?

BY ERIC KESTER

AT 2 A.M. ON MY NINTH DAY of troubleshooting, I lost my mind. I had expected to face some obstacles as an amateur app developer, but I hadn't foreseen this. Alone in a room whose landscape comprised ziggurats of crude design sketches and empty Red Bull cans, I was wrestling with a picture of bacon dumplings. It didn't have enough dots per inch for an Android smartphone screen, and I didn't have a version of Photoshop that would let me fix it. Even if I got my hands on a friend's copy,

I was looking at doing this all over again for the larger screen of the iPhone 6. And then God only knew if I would find the resolve to dream up special features for the 6 Plus. Frustrated and over-caffeinated, I switched tasks, checking to see if my app's interactive map worked. It geolocated me into the middle of the Atlantic Ocean. I slammed the laptop closed.

I blame my exasperation on the increased ease of entry into the app-development market. Having a world-changing idea is so common it's almost a side effect of smartphone ownership, but only in the past few years have regular people been able to turn concepts into reality. Five years ago I would have had to know Objective-C, the programming language for Apple iOS coding. But in 2010 dozens of user-friendly app-creation platforms appeared. In January 2010 there were 120,000 published iOS apps. Twelve months later there were more than 350,000 in the iTunes Store. Last year more than 6 million app developers existed in Apple's ecosystem.

If I was going to make a million dollars, which was (obviously) the plan, I needed my idea to capture the public's imagination. That idea? Bacon Now, a geolocation app that would provide directions to restaurants serving critically acclaimed bacon dishes in U.S. cities, starting with New York. The app would also include geofencing features: If a user wandered within 100 yards of, say, a bacon-infused bourbon cocktail, his phone would buzz with an alert.

Idea in hand, I spent a nonrefundable \$99 developer fee on an account through Apple's developer website. This granted access to a Software Developer Kit, where the actual programming takes place, and a video tutorial for learning some basics. I started playing the first video: "The G-L resolve-multisample-framebuffer Apple has now become"—at this point there is an expectant pause, as if the narrator were about to reveal the exceedingly simple secret to success in programming—"the G-L blit-framebuffer," he concludes. "It's pretty simple." I slumped back in my chair.

So I needed help. Thankfully, there's a lot of it out there. On a Pinterest-like site called dribbble.com, I found dozens of designers who could build Bacon Now, customized with whatever features my cholesterol-lined heart might desire, for around \$100 an hour, or \$10,000 in total.

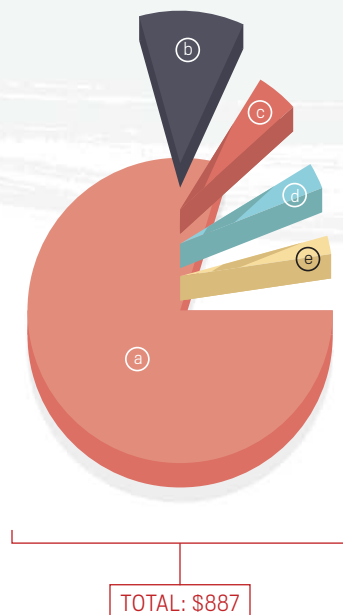
There was another option, appmakr.com, that would allow me to design an app the same way I would a blog on WordPress or Tumblr: Choose a few premade tabs; customize some colors, pictures, and headers; and the app is essentially complete. The downside: It's full of distracting ads.

In the end I went with Bizness Apps. For \$59 a month this service offered tabs that I could customize for each dish, a premade GPS-enabled map that I populated with my own data points, and a feature that let me draw circles around each restaurant for geofencing. Within the design dashboard was a simulator I could use to see instantly how my app functioned, like the Preview button in WordPress. When I was done I hit Publish, and my entire app was compressed into a bite-size file, ready to upload to app stores. The whole thing couldn't have been easier.

Or so it seemed until I was in my 50th or 60th hour of troubleshooting and tinkering, lubricating my aching eyeballs with industrial-strength Systane eye drops. Whenever I ran into a question I didn't know the answer to (is white font on a black background a design faux pas? If your app frequently crashes at the load screen, is that a design faux pas?) I looked for advice at lukew.com, the website of Luke Wroblewski, a product director at Google whose website aggregates advice from expert app developers.

Sometimes I came away with solutions. Always I came away with new ideas. What if I added background sounds of bacon sizzling, or a section for user-submitted photos? These ideas would lead to new questions, and eventually I'd be digging for answers within Bizness Apps' cavernous user forum. Most beginner-app threads, I found, start with "I have this problem . . ." followed by a flurry of responses along the lines of "Me too!" followed by, well, nothing else. At that point I'd email my Bizness Apps account manager, Jade, who was very helpful. She even occasionally logged in to my account to fix a bug herself, though I got the sense that any more intervention would require me to buy the premium White Label package for an additional \$10 per month.

This continual loss of money was as disheartening as the loss of time. With a \$708 annual fee to Bizness Apps, \$99 for Apple's developer fee, \$25 for Android's developer fee, \$40 to purchase hi-res



Expenses incurred:

- (a) Bizness Apps annual membership, \$708;
- (b) Apple developer fee, \$99;
- (c) image licensing rights, \$40;
- (d) Google Play developer fee, \$25;
- (e) domain for app home page, \$15



Bacon Now helps people with two vital tasks: finding nearby bacon (1), and learning about popular bacon dishes (2).

WHEN I WAS DONE I HIT PUBLISH, AND MY ENTIRE APP WAS COMPRESSED INTO A BITE-SIZE FILE, READY TO UPLOAD TO APP STORES. THE WHOLE THING COULDN'T HAVE BEEN EASIER. OR SO IT SEEMED UNTIL I WAS IN MY 50TH OR 60TH HOUR OF TROUBLESHOOTING AND TINKERING.

images for the app's icon, and \$15 for the app's home page, my expenses totaled \$887. Apple and Android take 30 cents for each purchase of the 99-cent app, so to break even I'd have to sell just over 100 apps per month. Considering Apple users download 2 billion apps a month alone, this figure seems achievable.

But that stat needs a bit of context: Two-thirds of smartphone users download zero apps per month, and the top 7 percent of most active users account for nearly half of all downloads—purchases that consist mostly of top-25 apps with huge marketing budgets. Search "bacon" in the app store and you'll see Bacon Now buried beneath other dreamers' work, including an app called Bacon Farts ("Now with 76 Awesome Fart Sounds!"). This is almost as demoralizing as my Android stats page, which tells me that, since the app went live a few days ago, I've tallied only one download. (Hi, mom.) It's too soon to tell how I'll do in the Apple App Store, but I think it's safe to say that Peanut Butter Now is delayed indefinitely.

Though Bacon Now has so far fallen \$999,999 short of my \$1 million goal, I can say that a nonprogrammer building a basic, functioning app is most definitely, sort of, doable. Bacon Now does what I planned, and while it won't have Google knocking on my door, it's not visually offensive. So I'm satisfied. I, a person who has only ever been called a computer genius after resetting his parents' wireless router by turning it off and then on again, have joined the revolution. I made an app, and you can buy it.

SAVIORS OF THE SNOWED-IN

Everything you need to get that blizzard off your driveway.



A few states where you can be fined for driving with snow on your car: Connecticut, Pennsylvania, New Jersey.

AS MUCH AS I love machines, I don't need another one to look after. So I don't use a snowblower. I shovel, and I have for more than 40 years, since I was a kid in Connecticut. The difference between now and then is that these days I'm smarter. I've learned that it's better to push the snow than lift it. If I do have to pick up snow, I hold the shovel close to my body. It's simple physics: The farther out you extend a full shovel, the harder you have to work.

My method: I clear a strip along the edge of the driveway and then push all the snow into it. Then I go work on something else. No sense spending all day pushing around old weather.

— ROY BERENDSOHN

1 TRUE TEMPER ALUMINUM COMBO SHOVEL, \$35

This shovel has a hybrid head that can push snow or lift it, and a handle that allows you to stand, not stoop. No stooping.

2 SAFE PAW ICE MELTER, \$17

A good deicer not only melts the ice you've got now, it also prevents the next storm from forming more of it. This one accomplishes both tasks with-

out poisoning your concrete, your pets, or the environment.

3 TRUE TEMPER SCRATCH-FREE SNOW BRUSH, \$15

The design of this brush allows you to reach into awkward nooks on your car where snow can hide, like beneath the wipers or behind the spare tire. And with the foam head, you can be aggressive without accidentally scratching the paint.

4 IRONCLAD TUNDRA GLOVES, \$65

Waterproof. Kevlar-reinforced. Insulated. And unlike the ski gloves you might have planned to use, they allow you to move your fingers.

5 SNOW JET NON-STICK SPRAY, \$8

Coating your shovel with a slippery polymer before shoveling prevents snow from sticking to

it and slowing you down. It's like spraying a frying pan with PAM but, you know, for tools.

6 THERMOS 16 OZ STAINLESS STEEL COMMUTER BOTTLE, \$30

When you're ready to take a break, press the button on the side of this insulated bottle to open it with one hand, even in gloves. Pro tip: A splash of Irish whiskey vastly improves both coffee and cocoa.

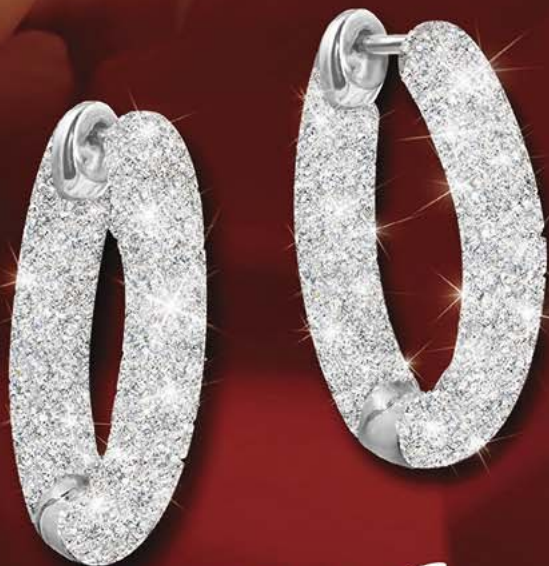
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point where the metal parts are rubbing it. Problem solved.

We just bought a new home, and the walls have a number of small bulges shaped like fastener heads. What are these, and how can we fix them before we paint?

Those bulges are called nail pops. They're created when drying lumber pulls away from the nail or screw used to hold the drywall in place. The fastener's head sticks in the drywall instead of pulling away with the lumber, which creates a telltale bump.

To fix yours, use a 5-in-1 painter's tool to scrape the drywall off the fastener's head. You know this tool: It looks like a putty knife with a hook-shaped blade. If what you find below is a screw, try backing it out. If you can't get it, leave it. If you find a nail, set it a little deeper.

Next, drive a 1¼-inch drywall screw above and below the nail pop. Apply a couple of coats of drywall compound. Now you can repaint.

Why does condensation form on the inside of our storm windows in the winter? Is there any way to prevent this?

Ideally, indoor humidity should be between 35 and 50 percent. The humidity in your home is probably well above that. The first place to look is the bathroom. If anyone is showering without running the fan, that has to stop. If the bathroom doesn't have an exhaust fan, you need to install one that vents to the outside (not the attic).

It's also possible that your furnace or boiler is not venting properly. Burning fuel produces moisture vapor, and this should be safely eliminated through the chimney. An unusual amount of moisture vapor in the air could indicate a partially blocked chimney vent. This would also set off carbon monoxide detectors in the house.

Finally, if your home is equipped with a humidifier on its furnace, reduce the setting on its control dial. Keep turning the dial back until you solve the problem.

ASK ROY

Popular Mechanics' senior home editor solves your most pressing problems.

BY ROY BERENDSOHN

The ceiling fan in my master bedroom is awfully wobbly. How can I make it true?

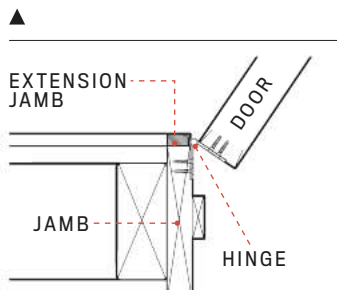
Assuming the fan was properly installed, it could be out of balance; this can be corrected with a fan blade balancing kit sold at a home center. They cost about \$5. More ominously, the fan may have been hung in an electrical box that wasn't rated to support it, or it could have loosened for a variety of other reasons: Its mounting screws may have missed the joist, for instance. This is more than an annoyance. I know of one case in which a ceiling fan fell and struck a woman sleeping in the bed below. She's lucky she wasn't hurt. For now, stop using the fan. Then either refasten the box to the framing or overhaul the entire setup with a new box rated to support the fan.

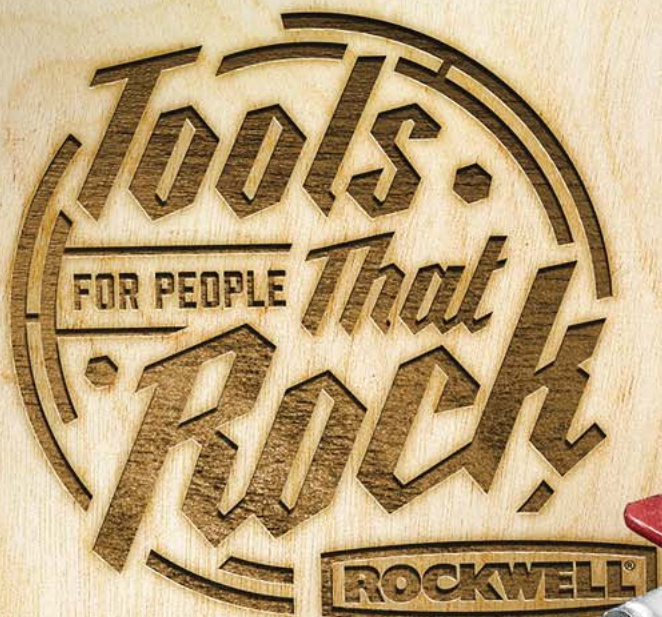
During a recent renovation our remodeling company took off a door to prevent it from being damaged, then set it back into its old jamb. Now it squeaks.

We've tried grease and oil on the hinge. Nothing works. Please help.

I suspect that what you're hearing isn't the typical metal-on-metal squeak. It's probably a metal-on-wood squeak from the rotating part of the hinge rubbing against the door's trim. It's possible that the remodelers added an extension jamb—a thin wood strip that increases the jamb's width—to your door (see diagram, below). Why would they do that? The wall itself is sometimes thicker after remodeling: They may have applied shims or a second layer of drywall to even out low spots. They would have needed to extend the jamb to make it the same width as the new wall.

If this is what happened, your door trim now sits right against the hinge. To fix the squeak, remove the door and the hinge. Lightly sand or carefully plane the trim to provide a little clearance at the





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Big, bulky circular saws have met their match. The Rockwell Compact Circular Saw weighs in at a mere 5 pounds without sacrificing an ounce of cutting capacity. Don't let the slim design fool you. The comfortable inline grip lets you make all the big cuts, even using just one hand. It maneuvers easily, especially overhead. And features a lower blade guard, like on traditional circular saws, for proven performance and dependability.



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THE INDISPENSIBLE STUD SENSOR

The best wall detectives can locate far more than studs. **BY ROY BERENDSOHN**

FEW MISTAKES CAN HALT A PROJECT as immediately as drilling into a pipe buried in your wall. One minute you're standing there, thinking about what's for lunch as the drill bites in, and the next you're calling a plumber with your feet cooling in an inch of water. All you need to avoid this potential disaster is a good stud sensor, which can actually detect all sorts of items. We tested three on the same wall to see how accurately they could differentiate the stud frame from the hazards lurking around it: a live wire, a steel pipe, and a piece of copper tubing. All of them would preserve your pipes, floors, and pride from the effects of a poorly located drill hole. They're also helpful for, you know, hanging pictures.

ITEMS YOU
MIGHT FIND IN
YOUR WALL



Cable



Studs



Copper
Pipe



Steel
Pipe



Steel
Protector
Plates



Lost
Tools



Buried
Treasure

★★★★★

STANLEY FatMax Stud Sensor 300 FMHT77407 **\$30**

LIKES: The FatMax edged out its competitors by reliably finding copper pipe, but it also located steel pipe, wood, and cable. The marking channel on the top can help you make an accurate pencil mark on the wall, even when you're holding the scanner above your head.

DISLIKES: The instruction manual might as well be in hieroglyphics.



★★★★★

CRAFTSMAN

Wall Scanner with
CenterVision 949067 **\$45**



★★★★★

ZIRCON

MultiScanner i520
OneStep **\$50**

LIKES: The Craftsman easily and repeatedly located steel pipe, wood studs, and a live electrical cable. It has operating instructions printed on its back and an over-the-stud alert that lets you know you've begun the calibration process in the wrong spot (on top of the wood).

DISLIKES: Had trouble locating copper pipe.

LIKES: After using this product, it's clear that Zircon builds Craftsman's model as well, so nearly everything said about the 949067 applies here. This scanner, however, also comes with a DVD how-to guide.

DISLIKES: Like the Craftsman, the Zircon found steel pipe but had trouble reliably spotting copper.

YES, BUT WHAT'S INSIDE A STUD SENSOR?

Most contain a small capacitive sensor, which streams a weak electric field into your wall. Dense objects alter this field, causing the sensor to beep. Basically, if you answered "elves, magical beans, and voodoo," you're not far off.

Popular Mechanics

BREAKTHROUGH AWARDS 2014



Popular Mechanics celebrated its 10th annual **Breakthrough Awards** on October 7 in New York City, bringing together the 2014 winners and special guests for lunch at the Hearst Tower and an evening gala in the penthouse of the Glasshouses at the Chelsea Arts Tower. Editor-in-Chief Ryan D'Agostino presented each winner with a symbolic Breakthrough hammer during the day, setting up a lively evening of food, drink, and performance by famed scratch DJ Richard Quitevis, aka Qbert. "It was a thrill to see such an outstanding group of innovators interacting and sharing ideas," D'Agostino says. The events included our four Next Generation winners, teenage inventors given special recognition by sponsor BASF.

Congratulations to all of the 2014 awardees. They are now part of the Popular Mechanics tradition of honoring innovators who are making the world a better place—and leading us all to a brighter future.

Top to bottom, left to right, with winners' names in bold: BASF's Klaus Harth and Ron Barry, Next Generation winners **Kamila Krawczuk**, **Shiloh Curtis**, **Kenneth Shinozuka**, and **Terrance Li**, and BASF's David Willison and Laura Enderle; chef and Popular Mechanics Contributing Editor Wylie Dufresne, Food Network Magazine Editor-in-Chief Maile Carpenter, Molly McCarthy and Colleen Kramer, representing **Boston Scientific**; DJ Qbert; Ryan D'Agostino, Local Motors' **Jay Rogers**, Publisher and CRO Cameron Connors; Ryan D'Agostino; **Roger Krulak** of Forest City Ratner Companies and **Brent Bushnell** of Two Bit Circus/STEAM Carnival.



This is the world's first family robot.
Cute, huh?
It'll be ready in a year, but people in the technology world
are already freaking out about it.
Some say it's too human.
Some say it's not human enough.
The woman who created it says they're missing the point.

BY [Billy Baker](#)

PHOTOGRAPHS BY [Tuukka Koski](#)

THE JIBO



The mansion sits in a clearing amid old-growth trees, a gorgeous home at the end of a long driveway off a shaded street off a winding road. Farmhouses dating to the Revolutionary War sit at the edge of hilly meadows. The roboticist strolls across the lawn wearing a simple blue dress, the lush grass cool under her bare feet. Her black hair ►

CONTROVERSY

A close-up, high-contrast photograph of the Jibo robot's head. The robot has a black, rounded head with a white, oval-shaped face. Two small, circular sensors are visible on the top of the head. The background is dark, and the lighting highlights the robot's features.

Jibo is the brainchild of Cynthia Breazeal, head of MIT's Personal Robots Group.

hangs below her shoulders, and she waves as she walks through the metal gate that separates the sprawling front lawn from the swimming pool behind the house.

"Beautiful, isn't it?"

She extends a hand and shakes hard.

"Oh, this isn't mine," she says, waving at the grounds and tucking her hair behind her ear. She has tan skin and high cheekbones, almond eyes and a sleek smile, and the strong voice of a busy mother. "It belongs to one of my investors. They just let us work here."

Cynthia Breazeal is an associate professor at Massachusetts Institute of Technology, in Cambridge, and the founder of the Personal Robots Group at the MIT Media Lab. She is one of the world's leading pioneers in the field of social robotics, which essentially is the science of making robots act more like humans. She has been working for two years on a product called Jibo, a machine she describes as a family robot because she envisions a day when every household will have one on the kitchen counter, playing an active and cheerful role in not only managing daily life but in making it better. Earlier this year Breazeal launched a campaign on the crowdfunding site Indiegogo to raise awareness of Jibo and to help fund her company, Jibo, Inc. She set a goal of \$100,000. In two months donors gave her a total of \$2,228,409.

The pool house behind the mansion—Jibo, Inc.'s satellite office—could accommodate a small family. It's quiet here, free of the distractions of Cambridge, and Breazeal and her team can work in focused solitude. More than 4,800 Jibos have been preordered, and Breazeal has promised to start shipping in late 2015—just under a year from now.

In the pool house two Jibo employees sit in overstuffed chairs in front of large windows, laptops in laps. A man wearing a Jibo T-shirt cleans off the granite countertop of the small kitchen. "This is actually where we shot a lot of the scenes in the Indiegogo video," Breazeal says. In that video you see Jibo taking photos of a large family at a birthday party. You see it greeting a single guy coming home from work, asking if he'd like for Jibo to order Chinese takeout. It reads a story to a little girl at bedtime, acting it out in different voices. It reminds a woman who's baking a pie that her friend will soon arrive to take her grocery shopping.

"And it does all those things without you having to keep reaching into your pocket to pull out a phone," Breazeal says. "It's just there for you, all the time."

The utopian households in the promotional video are a little over the top, and some members of the gadget-watching cognoscenti have called Jibo weird, creepy, unnecessary, a silly attempt to alter the course of human existence that actually just takes pictures and tells you when you have a phone call. The consumer-technology landscape is a battlefield. New products are picked apart as soon as they're announced, with every pixel and micron getting parsed and analyzed and naysayed by experts. The thing with Jibo is, because Jibo, Inc. is not Apple, Breazeal has had to make her efforts public long before there is a product to buy—long before her product is anything close to the way

IF THE SMARTPHONE WAS THE END OF BOREDOM, JIBO PROMISES TO BE THE END OF BEING ALONE.

she wants it. And not all the experts seem to understand the way she wants it.

Breazeal, 46, is a mother of three, ages 9, 8, and 6. She likes to say that she's never in any photographs of her family because she's always behind the camera. That everyday mother's lament is not exactly what drove her to create Jibo, but it's not insignificant to the robot's genesis. She wants Jibo to be a friendly pres-

ence in the house to fix little problems like that one, because fixing little problems can make a moment better, and moments are what make up a life.

A white Jibo prototype sits on the counter.

She asks the man in the T-shirt, "Okay?"

"Yeah," he says.

Breazeal stands a few feet from Jibo and says, in a voice only slightly different from the one she uses to talk to humans, "Wake up, Jibo."

Nothing.

Breazeal looks at the man.

"Wait," he says, adjusting, fiddling. "Hold on. Okay. Go ahead."

Again Breazeal looks at her robot and says with purpose and hope, "Wake up, Jibo."

The robot's round head twists on its base, a remarkably human wiggle. A white circle appears on its round screen, like an eye opening. In a voice like an animated movie character—cute, cheerful, but not treacly or grating—Jibo responds, "Hello, Cynthia!"

A

LOT OF PEOPLE USE the phrase robot servant when they talk about Jibo, alluding to some kind of *Jetsons* machine that brings you a drink when you get home. In a subsequent meeting with Breazeal, I make the mistake of repeating those words.

Up until this point things have been casual, a spirited conversation on a Friday afternoon back in her office at MIT. Breazeal is wearing a peach shirt, hair pulled to the side, and the sun is making her office glow, illuminating the *Star Wars* memorabilia, including the framed photo of her with George Lucas, and an R2-D2 in a large box. *Star Wars* was the movie that started her fascination with robots. She has been trying to make R2 real ever since.

But as she straightens up her office before the weekend, she is informed that an article has just been published on wired.com, a think piece that asks the question: Is a life lived with a robot servant the kind of life we want to live?

She sighs and says, "It's not living with a robot servant." She sounds exasperated and annoyed, like a

mother telling her child for the 11th time to please get his feet off the seat. "Calling it a servant just automatically puts it in a very old-fashioned bucket of the robot servant of the 1960s." She speaks more loudly and animatedly, having left her office and now walking down the open stairwell inside the atrium of the Media Lab, squeezing past colleagues in this bizarre hub of innovation that looks like Willy Wonka's Chocolate Factory for the TED generation. "That's like the unmodern view of what this and so many other things are about." At the bottom of the stairs she stops and laughs at herself a little for getting worked up. "Anyway."

Criticism is largely new territory for Breazeal. She's had a long and distinguished career in robotics at MIT, first in the Artificial Intelligence Lab, and, since 2001, in the Media Lab's Personal Robots Group. But for the first time Breazeal isn't just showing the world something cool. She is selling it.

With Jibo she has had to step out of the lab and answer questions. The first, which I ask when she calms down—following more shouts of "completely wrong" and "totally uninspired"—is the most obvious for anyone selling a gadget: Why do I need it?

Breazeal gestures emphatically at the smartphone I'm carrying. "One of my pet peeves about technology is, these are individual devices," she says. "When you have a technology that's designed for an individual, what do you get? You get whole families sitting around the dinner table with their face in their device, pushing away and excluding the other people. I have three boys, and they love these damn things, and they pick them up and they stick their faces in it, and they walk off, and I'm like, 'Sweetheart, I am still talking to you.'"

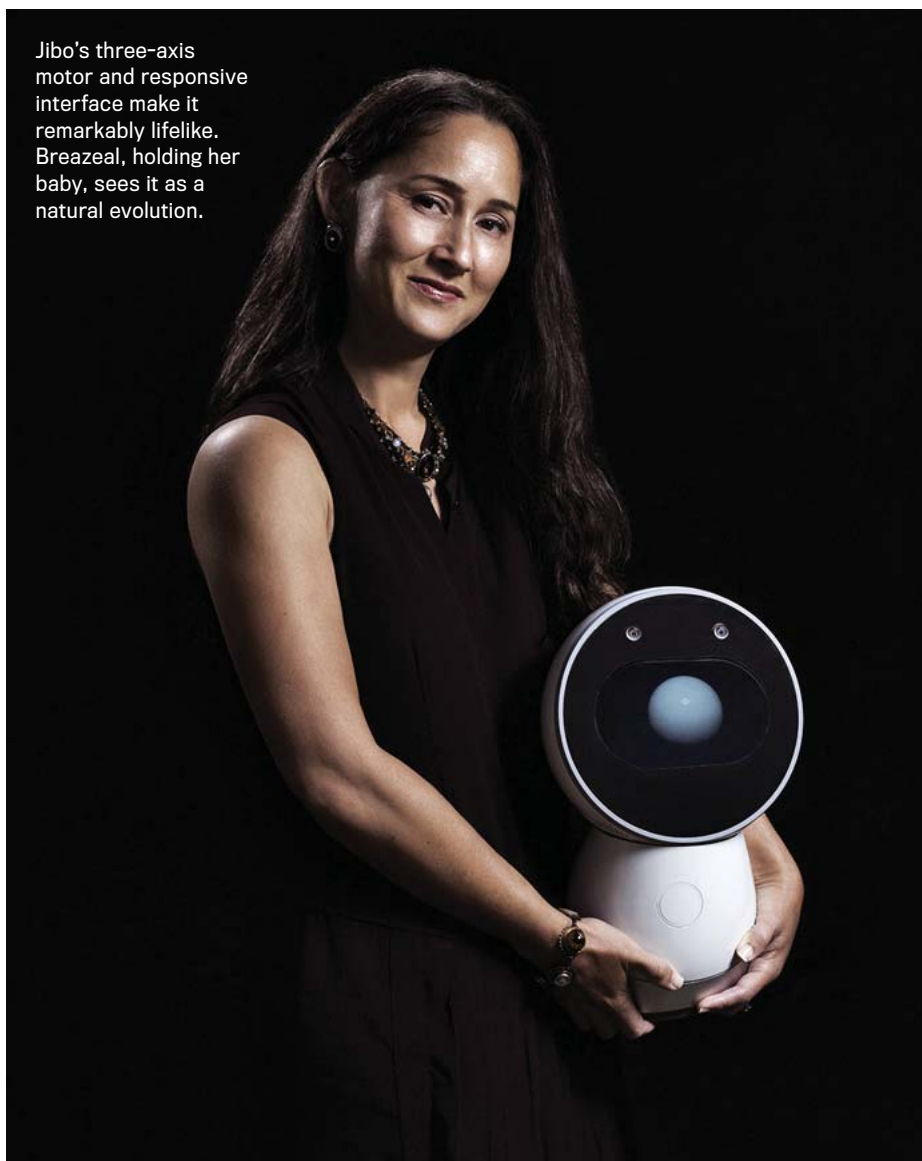
Jibo, she says, is not an individual device but a family device. "It's the first kind of technology that allows you to stay in your life, in the real world, in the moment, rather than say, 'I've got to stop what I'm doing, I've got to find my device, I've got to pick it up, I've got to enter my code, I've got to open the app—and then I can go back to my life.' That's what our relationship with technology is today."

Social robots are not a tool, she argues. They are a partner. Tools force you to leave the moment. Jibo, she argues, will allow you to access all that information and technology while you stay in the moment—while you stay in your life.

I rarely record interviews, but my right hand, the one

I use to write, is in a cast today, so I'm using my smartphone as a digital recorder. The reason I avoid microphones and recorders and, worst of all, cameras, is that if you train one on a human, it inspires performance, a personal encounter outsourced to something or someone that is not actually present. As Breazeal makes her case for Jibo, something happens: She starts talking at my phone. She sounds like someone being interviewed

Jibo's three-axis motor and responsive interface make it remarkably lifelike. Breazeal, holding her baby, sees it as a natural evolution.



rather than someone just talking. And this, perhaps above all else, is what Jibo eliminates. Like prayer for the devout, with Jibo the idea is that you do not feel like you're talking to yourself or even to a machine. You feel like you're talking to someone.

Seven years ago, not far from MIT, I was walking down the street, days into owning my first smartphone, when rain began to fall. I ducked under an awning to wait it out, and in a gesture so familiar now it's hard to believe it had meaning then, I reached into my pocket

Breazeal hopes for when Jibo becomes widely available. It won't be in your pocket. It will surround you. And you will talk to it. And it's a cute little cartoon of animated aluminum. If the smartphone was the end of boredom, Jibo promises to be the end of being alone.

THE MACHINE ITSELF IS A 6-POUND TABLETOP DEVICE,

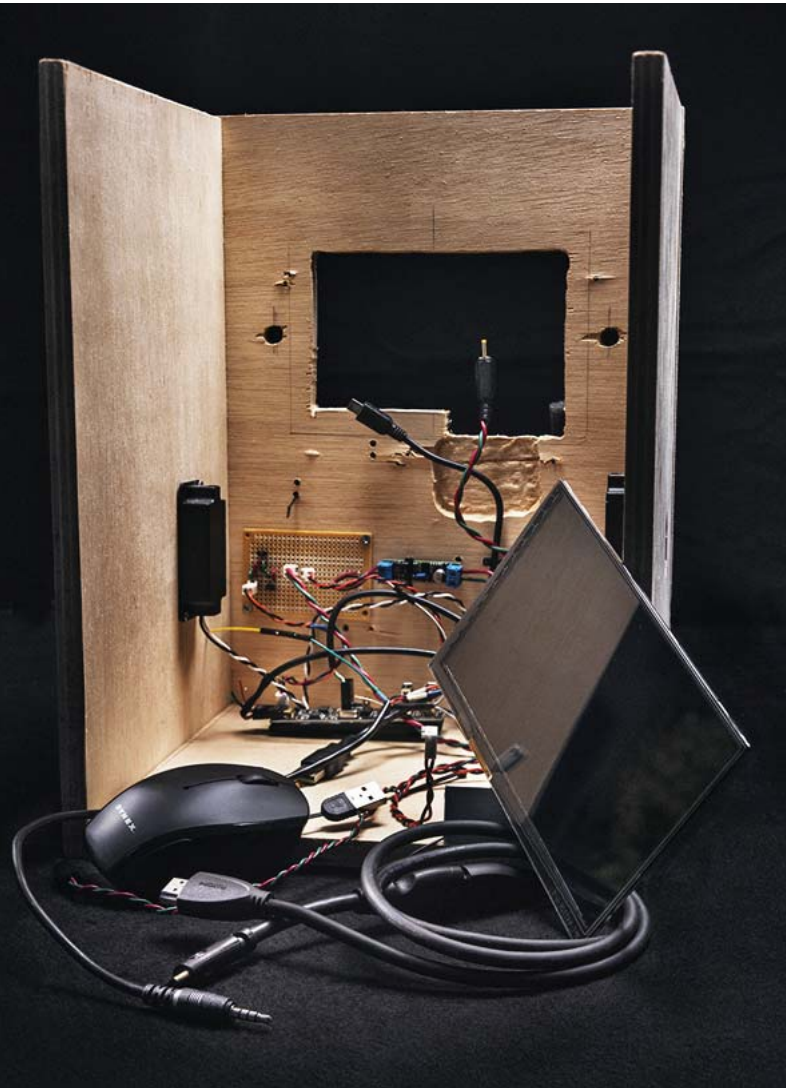
11 inches tall, that looks like the love child of Kenny from *South Park* and the robot Eve from *WALL-E*—small, rounded, spritely, mischievous. There is a dark, 5.7-inch touchscreen where its face would be, and on it an orb that is remarkably adept at implying human facial expressions. Hidden away in the head are stereo speakers and microphones, as well as tracking cameras that will allow Jibo to identify and follow people around the room, observing and interpreting and offering suggestions if, say, it recognizes that you're cooking and your hands are dirty and your friend has just texted. Jibo is designed to take candid photos—the kind Breazeal says she is never in—at your command. For video chatting, the tracking function will allow the user on the other end to control what Jibo is looking at, permitting grandma to chase the grandkids around the house.

Jibo is in fact ideal for the elderly, Breazeal says, both for emergency communications and also for companionship itself. A few years ago I bought an iPad for my 85-year-old grandmother, who lives alone. As I did, I felt extreme guilt, as if I'd passed her off to a digital babysitter. But she now refers to the iPad as her boyfriend. For the first time since my grandfather died 16 years ago, she says it feels like there's someone waiting for her at home.

Jibo has just a few main body parts that allow all of this: a head and a swiveling torso, slightly offset on a pedestal base, and a three-axis motor system so that the interaction among the three can further convey human gestures—a knowing glance, a curious head tilt, the technology of emotion. Breazeal is big on gestures of emotion. She's the kind of person who hits you when she's making a point.

The emotion part, or the companionship part, is where cool can drift toward creepy. In that promotional video for Jibo, when it's reading a bedtime story to the little girl, the robot is expressive and engaging. (Jibo operates on a Linux-based platform, so developers can create apps and games that take advantage of that expressive delivery of information. Breazeal is also the codirector of MIT's Center for Future Storytelling.) But you can see how this is not a child listening to a book on tape or watching an interactive e-book or a movie. This is a child being read a story. Yes, the reader of the story is a computer. But to a child born in an age in which cars tell her parents when to turn left and her favorite cartoons can be streamed to the television at any time, this will not seem like a big deal at all.

Breazeal continues through MIT's campus, down the Infinite Corridor, past a couple of dozen students juggling in Lobby 10, then out onto Massachusetts Avenue, past the school's nuclear reactor, until we arrive



Breazeal still keeps this early prototype, in which her team tested Jibo's audio and video components.

for my phone. As I swiped through the apps, still a new world of discovery back then—a digital Swiss Army knife—I came to realize that I was essentially looking for an umbrella. Something that would let me continue with my life despite the rain, or to pass the time, or to entertain me, or to accomplish a task.

Plus, waiting for the rain to stop is boring, and under that awning I also realized I would never be bored again.

That kind of before-and-after moment is what

at the MIT Museum. She is talking and making points and hitting me the entire time.

At the ticket counter Breazeal goes through a polite fumbling routine in which she pretends they won't know who she is.

"How does this work? I just show you my MIT ID?" Breazeal says. "I haven't been here in so long."

"Oh, you don't have to pay," a woman at the counter coos. (The woman will later say to me, "I was jealous that you got to go up there with her. She was stalling. She knew I knew who she was.") We ascend the stairs to the second floor and arrive at an exhibit entitled "Robots and Beyond: Exploring Artificial Intelligence at MIT." At the far end of the room, in a glass case, a robot called Kismet, the world's first robot capable of social interaction, waits for her like a taxidermy owl. As a postdoctoral fellow in the AI lab in the 1990s, Breazeal led the team that created it.

As we walk slowly and in unison—the museum walk—Breazeal glances at the other robots in the room, all of them groundbreaking, many of them with her handiwork inside them. She gives academic descriptions of each, all very interesting. But the flick of her eyes, the tilt of her body, is toward Kismet.

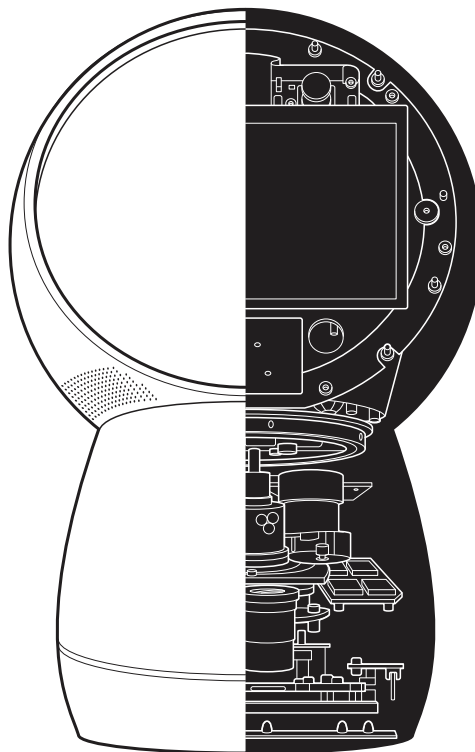
It looks like a head made from an Erector set, more gremlin than human, but even unplugged it has an eerie presence, as if it might start moving at any moment. It has big orange lips and paper ears, but it is the eyebrows and eyelashes around the richly detailed eyes that make the hair on the back of your neck stand up.

Breazeal spends a long, still minute looking at the assemblage of metal and wires. "It's the first," she says, softly, slowly. She looks like someone seeing a photograph of an old friend with whom she has fallen out of touch. "It's the first of its kind."

She is no longer talking to my smartphone.

"Kismet had a lot of charm. When you create something like a social robot, you can experience it on all these different levels. You can think about it from the science standpoint and the engineering standpoint, but you can experience it as a social other. And they're not in conflict. When Kismet would turn and look at you with its eyes, you felt like someone was at home. It was like, I feel like I'm talking to someone who is actually interpreting and responding and interacting with me in this connected way. I don't feel like it's a dead ghost of a shell. I actually feel the presence of Kismet."

We leave the museum and walk up Massachusetts Avenue toward Central Square so Breazeal can hop on the subway to her home in Harvard Square. All around us people are staring at their phones, listening on ear-



Stand and Deliver

Jibo is stationary—but otherwise fully interactive. Here are the robot's vital stats.

- About 11 inches tall, 6 pounds
- Body made of aluminum, plastic, and glass
- "Face" is a high-definition LCD touchscreen
- Two high-resolution cameras recognize and track faces, snap photos, and facilitate video
- 360-degree microphones and natural-language processing allow you to talk to the robot from anywhere in the room
- Can be connected to both Wi-Fi and Bluetooth

buds. Alone. Together.

What's scary about social robots—the human machine—is precisely what Breazeal argues is most human about them. This is the moment, she believes, historians will look back on and recognize as "the time when we appreciate that technology has to actually match how we experience and think and act and decide,

so that we become more empowered. That's the shift: the humanization of technology to serve human values." It's the same kind of slightly terrifying optimism that made people call Alan Turing and Steve Jobs crazy, back before anyone knew whether their ambitious machines would actually work.

As she departs, Breazeal stops and takes one final shot at those two words: robot servant.

"That is so brain-dead," she says. "It just annoys me."

And then she smiles, and hits me.

TO CALL JIBO A ROBOT SERVANT "IS JUST SO BRAIN-DEAD," SAYS BREAZEAL. "IT'S COMPLETELY WRONG AND TOTALLY UNINSPIRED. THAT IS THE UNMODERN VIEW OF WHAT THIS IS ABOUT."



A
YEAR

O F 2

G O 0 D

T H 1 N G S

As we look ahead to 2015, the world of technology gives us many reasons to be optimistic. Maybe even downright joyous.



#

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#5

• JANUARY 2015

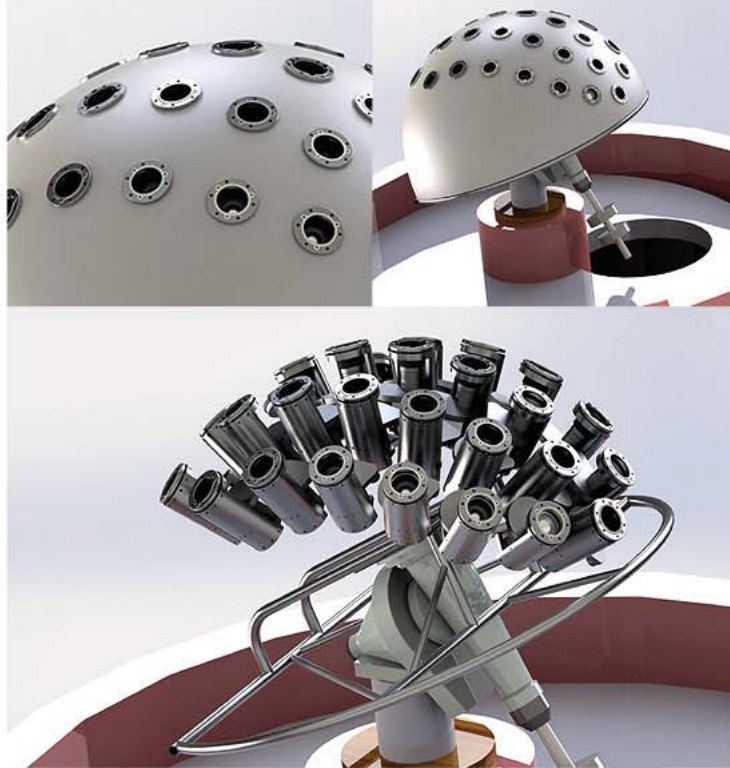
• FEBRUAR

▲
ANTICIPATED
DATE

5



In March astronaut Scott Kelly begins his mission to spend a year in space, the longest time ever for a U.S. astronaut.



#2 In early 2015 researchers at the University of North Carolina will begin using the Evryscope, a telescope that continually records 9,000 square degrees of sky. This will let astronomers study brief phenomena like gamma ray bursts that happen in small patches of sky, along with images from the time periods immediately before and after the event.



#3 By January 1 California will have finalized laws for operating autonomous cars on public roads.

#4 The Web gets faster on our phones in January. Thanks to a new HTML code called <picture>, instead of loading large image files regardless of the device you're using, browsers (Chrome and Firefox for now, with others following soon) will adapt downloads

based on perceived screen size and signal strength. This will reduce the size of Web pages and download time considerably.

#5 A TV version of *12 Monkeys*, the surprisingly good apocalyptic time-travel movie that earned Brad Pitt his first Oscar nomination, premieres January 16 on the Syfy network.

#6 After a beta launch at the end of 2014, Microsoft will roll out the official version of Skype



#7 HBO's *The Wire* should finally be available in HD. Not that that does anything to help Wallace.

Translator, a real-time audio interpreter that might lead you to purposely call a wrong number in Romania just to watch it work.

#8 If it gets through Congress, the Revitalize American Manufacturing and Innovation Act will

establish a network of U.S. industrial hubs to spur innovation.

#9 Similarly, the Wi-Fi Innovation Act should become law, opening a new spectrum of wireless for public use. (That bandwidth is currently reserved for interaction among smart cars, which seems less than effective.)



#10 By opening day on April 6, Major League Baseball will have incorporated a series of play-tracking cameras and sensors in all 30 ballparks, opening the game up to a whole new set of analytics by capturing metrics like bat speed, a player's reaction time, and distance covered to make a catch.

#11 Not to be outdone, the National Hockey League also hopes to start its own version of player tracking in time for the 2015-16 season, allowing for analysis of ice time, hits, shot speed, and other data.

#1

#10

• MARCH

• APRIL



#13

The United States Postal Service will release the Steve Jobs commemorative stamp: a quaint honor in a medium Jobs pushed toward obsolescence.

#12



This summer the U.S. gets Toyota's first fuel-cell car, the FCV, with the promise of a charge that lasts for 310 miles. On the rare occasion that you'd need it to, your fully charged FCV can also power the average home for up to a week.

WHAT I'M LOOKING FORWARD TO

Mark Hatch
COFOUNDER AND
CEO OF TECHSHOP



Romibo, from **Origami Robotics**. It's a robotic educational companion designed for teachers and parents of children with developmental disorders, and it speaks 26 languages.

#14 The more we adapt to the Internet of Things, the more modems we're going to need. And we're going to need them to be very, very small. Throughout the year Intel will be working the XMM 6255 modem into various smart devices. Barely the size of a Steve Jobs commemorative stamp (see above), the 6255 allows even the thinnest and smallest wearables and smart devices to communicate.

#15 Starbucks rolls out its new **Duracell Powermat mobile-charging pads** in stores nationwide.

The pads, which are a little larger than a coaster, are embedded in tables and counters and will charge any device via inductive charging, as long as it is protected by one of Powermat's cases.

#16 Verizon's long-awaited mobile TV service is expected to launch by June, possibly even offering à la carte channel selection.

#17 That same month **commercials get quieter**. For real this time. Nothing really happened back in 2011 when the FCC regulated



the volume of commercials, so they're trying again. The agency will update the algorithm for measuring volume, saving you from grabbing the remote every time *Sleepy Hollow* (see page 90) goes to commercial.

#18 Starting with this year's College

World Series (June 13 to 24), the NCAA is switching to flat-seam baseballs, which, on average, travel 20 feet farther than raised-seam balls. So: more home runs.

#19 **Plastc**, an e-ink device that replaces your credit cards and RFID cards (like your work ID), ships this summer. Once you store all of your credit card information on your phone, Plastc receives that data via Bluetooth and automatically changes its face and magnetic strip to become the card you

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• MAY

• JUNE

select. At \$155 it's too expensive, but the technology is impressive—and worth it if you really hate carrying all those cards in your pocket. Until Near Field Communication payments take over in a few years, this may be the most advanced wallet technology you can have.

#20 Now that tests are complete, scientists at two Australian universities plan to find a commercial partner to launch the first printable solar panels. Among other things, the ability to print panels on any plastic surface means that your cellphone case could also double as a solar charger.

#21 Samsung promises to incorporate foldable screens into some of its phones, tablets, and wearables by the end of the summer. This could lead to phones that expand into tablets, or even tablets that fold up and fit in your pocket.

Summer movies!

(#22) *Avengers: Age of Ultron*. (#23) *Mad Max: Fury Road*. (#24) *Jurassic World*. (#25) *Terminator: Genisys*, the first of a rethought trilogy in the Terminator franchise. (#26) *Assassin's Creed*. (#27) *The Fantastic Four*, a reboot with Michael B. Jordan and the lovely Kate Mara.



▲ Clockwise from top: *Mad Max: Fury Road*, *Avengers: Age of Ultron*, and *Jurassic World*.



#28 Also this summer, Carlsbad, California, startup Ostendo Technologies will release mini projectors capable of producing 3D holograms. They're small enough to fit into phones, so your next cellphone might be capable of projecting 3D images above your screen—a good thing for online shopping and a dangerous thing for Snapchat.

#29 With major manufacturers and cellular carriers on board, starting in July the Cellular Telecommunications Industry Association will require all new smartphones to come with a kill switch that lets consumers remotely wipe the contents of their phones in case of theft.

#30 Marvel Entertainment and Netflix have teamed up to present four new 13-episode superhero series throughout the year (*Daredevil*, *Jessica Jones*, *Iron Fist*, and *Luke Cage*).

#31 With the 2015–16 school year



WHAT I'M LOOKING FORWARD TO
David Rose
MIT MEDIA LAB VISITING SCIENTIST

Mainstream recognition of what I call enchanted objects. They exist at the intersection of computer coding, hardware, the Internet of Things, and human existence in an increasingly technology-enabled world. Enchanted objects care for us rather than requiring that we care for them. They recharge themselves via solar power, harvesting energy from human motion or simply finding their own plugs. They respect our attention by presenting ambient information, not just text.

Florida shifts to requiring all-digital instruction materials in its public school system. Convenient, light, and much easier to search.

#32 **Apple CarPlay,** which basically gives your dashboard all the capabilities of your iPhone, expands to five automotive brands by the end of the year, with 24 more coming.

#33 Timed to coincide with the fall release of *Halo 5: Guardians*, *Halo*, the Steven Spielberg-produced series centered on the video-game franchise and its main character, Master Chief, premieres on Xbox Live.

#34 Good news: At this fall's annual meeting in Paris of the Parties to the Montreal Protocol (the group of nations that signed the treaty in the 1980s to reduce CFCs and other atmosphere-destroying chemicals), scientists



#35 Will Forte's futuristic-apocalypse comedy, *The Last Man on Earth*, premieres on Fox.

#36

By the end of 2015, Scott cycling apparel will incorporate ITD ProTec technology into its clothing. The fabric already had carbon fiber woven in for durability and will now also have a light ceramic coating (tough dots in hexagonal patterns) in certain vulnerable spots like hips and shoulders. The coating spreads the impact and abrasion of a fall over the clothing's surface, helping to keep it—and your skin—intact.



are expected to release a full report showing that the world's efforts are working and that **the hole in the ozone layer has gotten appreciably smaller.**

#37 By October MasterCard and Visa plan to fully implement the much safer credit card system the rest of the world already uses, called EMV. Instead of traditional magnetic strips, EMV relies on an embedded microchip and PIN, which are much less

susceptible to hacking. And only moderately less cool than the Plastic e-ink card (see #19).

#38 In late 2015 **NASA** will conduct the first life sciences experiment to take place on another planet by sending a high-tech greenhouse to the moon on one of the rockets competing for the Google Lunar X Prize. The miniature greenhouse will contain measurement equipment along with basil and turnip seeds. Success



would prove that the moon can sustain food- and oxygen-producing materials—and get humans one step closer to living there.

#39 In-flight wireless should become truly usable by the

end of 2015. AT&T promises to bring to flights the cell speed you're accustomed to on land by building an air-to-ground LTE network. You'll be able to use your own data plan instead of buying a Gogo pass, and since you're no longer sharing with everyone else, it also means you'll be able to watch video, like those remastered episodes of *The Wire*. Even in HD.

#40 *Star Wars: Episode VII* comes

#33

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● OCTOBER

● NOVEMBER

out on December 18, starting a run of as many as six new films in the series being released, one per year, until 2020. Best to start prepping the kids on the originals now.

#41 The FAA has promised to release **new rules for drones operating in national airspace** by the end of 2015, which probably won't affect your life immediately but will be good news if any of these drone delivery services ever takes off.



#42 Before the end of the year Fujitsu plans to launch **touchscreens that use ultrasonic vibrations of varying intensity to let you "feel" textures.** The technology could be very useful for the visually impaired and—

A Y E A R O F 2 G O O D T H I N G S

like anything else in computers—gamers and pornographers.

#43 Yahoo will follow Gmail's lead by making its email service fully encrypted and compatible with Gmail (for now you have to email within the Yahoo/Gmail universe), meaning all of those top-secret emails you've been sending are safe. No one other than your friends will know that you're looking forward to Scrabble and will be over at 7:30.

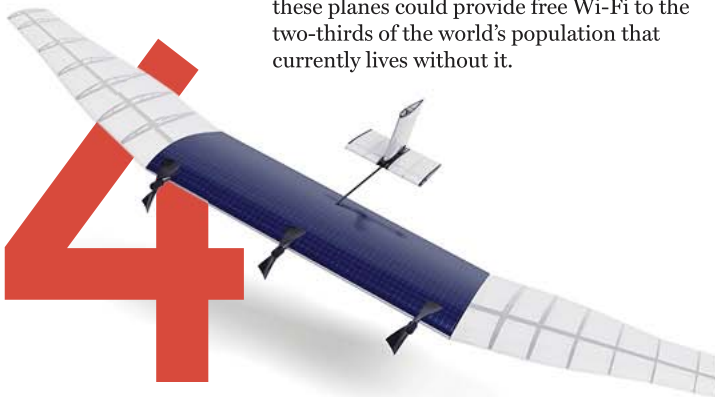
▼
2015: THE YEAR OF THE BATTERY
This will be a huge year for battery life, thanks to two new microchips. The first, from Ineda Systems, uses three processors—one that constantly runs in the background, drawing little power and accomplishing continuous tasks like motion sensing or Bluetooth connectivity, and two that pitch in when more power is needed. The Ineda chip lets the device's main processor sit dormant whenever possible. The second microchip, from PsiKick, takes advantage of the slight current that constantly runs through a transistor, even when it's not being used. (Think of it like the vampire power that's drawn through your TV, even when it's off.) Although that current barely affects battery life, it can be used for small tasks on a device. So instead of draining the battery every time your smart watch senses you've raised your wrist, activating the screen, the PsiKick uses the little bit of latent energy that's already there. The company estimates that its transistor uses as little as one-tenth of 1 percent of the power used by traditional options. Great for that watch you're wearing. Even better for a pacemaker.



WHAT I'M LOOKING FORWARD TO
Tom Kalil
WHITE HOUSE
DEPUTY DIRECTOR
FOR TECHNOLOGY
AND INNOVATION

In 2015 researchers will begin to make progress on the goals of the president's BRAIN Initiative, including the ability to take a dynamic picture of the brain in action. This will improve our understanding of how the brain works and give researchers new tools to diagnose, treat, and prevent diseases such as Alzheimer's and ALS.

Facebook hopes to test its solar-powered Wi-Fi airplanes (not drones—the company gets angry when you call them drones, and you don't want Facebook angry) by the end of the year. If successful, within five years these planes could provide free Wi-Fi to the two-thirds of the world's population that currently lives without it.



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The Moonbeam Series II Turntable

EIGHTEEN POUNDS OF ANALOG ENGINEERING are tucked inside this minimalist record player. What you can see of the table, and what you can't, all work together to isolate the needle and record from any disturbance that would otherwise muddle the quality of the music coming out of your speakers. Even the feet it stands on are designed to absorb vibrations.

Inside the sound-dampened shell, which is encased in an American cherrywood veneer, the AC motor—smoother and more consistent in speed than DC motors—hums left of center. The motor drives a low-tension belt around a pulley system. The belt connects to a bearing cup made of self-lubricating Teflon plastic; it turns more quietly than more expensive metal-

A BEAUTIFUL THING



bearing setups. A metal spindle rises out of the bearing to the subplatter, on top of which is the main platter where you rest the vinyl. Both platters are formed from high-density polymer that traps and dissipates the resonant energy caused by all the spinning and humming and turning of the machine's intricate guts. You'd hardly know the equipment is in there working,

given the hush when the record turns, and the spare looks of the exterior. And that's the whole point. — MATT GOULET

Company: *Sota Turntables*
Owners: *Kirk and Donna Bodinet*
Location: *Worth, Illinois*
Photograph by *Kenji Aoki*

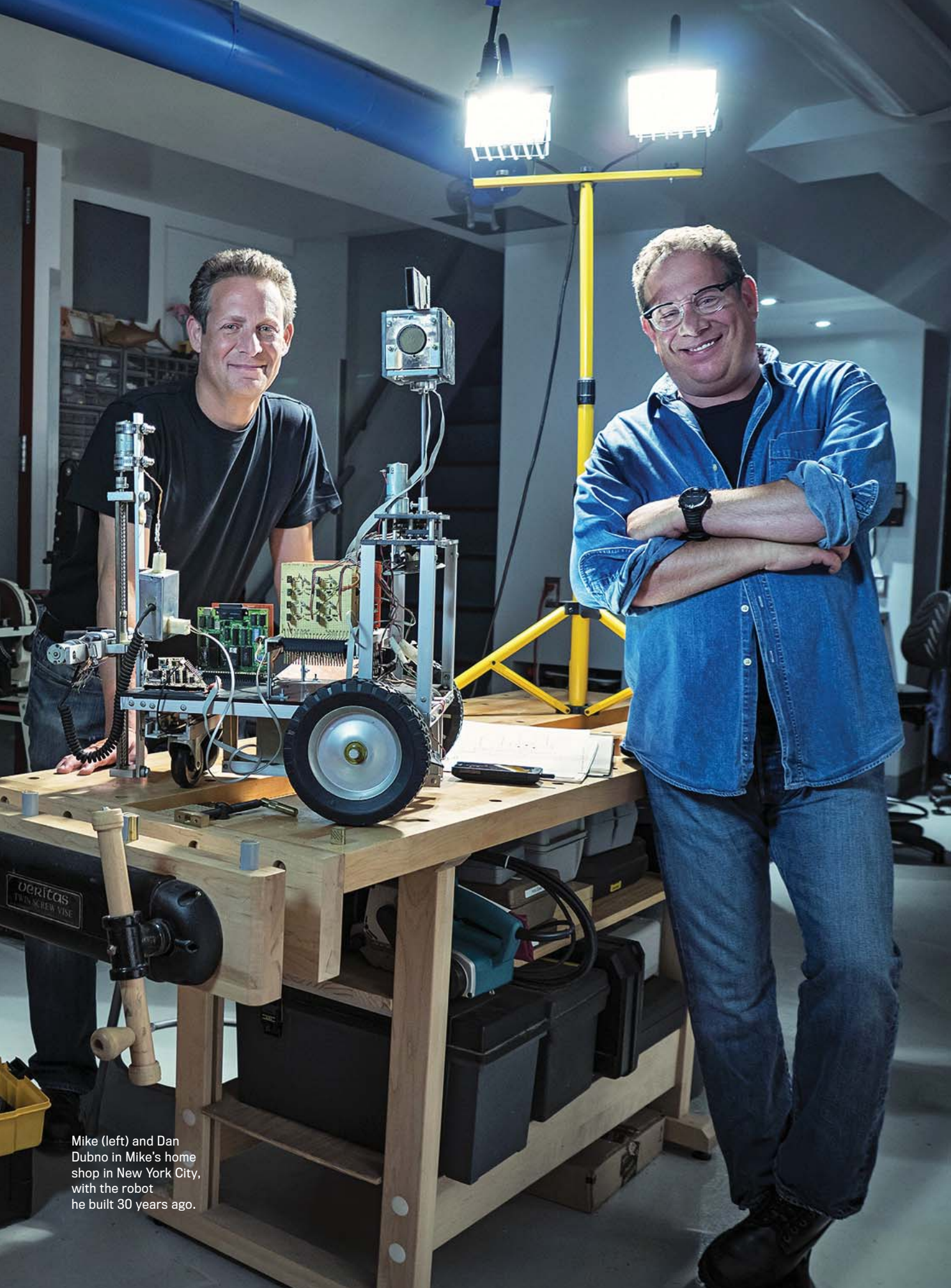


STATS

09 turntables
in the Sota line.
*The Moonbeam is the
entry-level player.*

05 hours
to put together a
finished table.

60 Moonbeam
units they've
produced this year.



Mike (left) and Dan Dubno in Mike's home shop in New York City, with the robot he built 30 years ago.

THE GADGET T-BRO THER

BY

SCOTT EDEN

PHOTOGRAPHS

BY

DALE MAY

MIKE AND DAN DUBNO ARE MASTER TINKERERS WHOSE INNOVATIONS
HAVE ALTERED GLOBAL FINANCE AND TELEVISION NEWS.
BUT THEIR GREATEST CREATION IS GADGETOFF—A CHAOTIC FESTIVAL
WHERE TECHNOLOGY'S BIGGEST NAMES GATHER TO FLAUNT
PROTOTYPES, BLOW STUFF UP, AND PEER STRAIGHT INTO THE FUTURE.

A

A DOZEN YEARS AGO, when Mike Dubno was looking for a home on Manhattan's Upper West Side, a realtor showed him a six-story brownstone on a serene cross street not far from Central Park. The building was nice enough, but what really seduced Dubno was something the engineering inspector mentioned. He noted that a previous owner had divided the building into multifamily dwellings, and in so doing had installed 400-amp electrical service. "You know," the engineer said, "you could run a machine shop in here."

One of Dubno's priorities after moving in was to excavate a half-million pounds of bedrock in order to convert his dim, 19th-century grotto of a basement into a 900-square-foot workshop roughly the size and shape of a railroad apartment. Dubno then installed a Smithy lathe and milling machine he would control by a computer he built from scratch. He has a Jet drill press capable of 5,000 rpm, which he concedes is "a ludicrous drill press for an individual to have." He has an Epilog laser cutter and a MakerBot 3D printer. He has a TIG welder and a MIG welder and a Hypertherm torch with a 55,000-degree-Fahrenheit beam of ionized plasma. An industrial-grade air-filtration system with a 1-micron filter sucks stuff—the superfine particulate dust that results from matter that's been cut by a plasma torch, say—out of the air. When he fires up the Oneida vacuum that powers the system ("This is overkill . . . by a lot"), it emits a rising, multipitched *whoosh* not unlike the sound effect used for death rays in B movies.

On the room's several benches are motherboards in varying stages of deconstruction, a *Short Circuit*-esque robot Dubno built three decades ago when he was about 20, powerful magnets that if not stored properly

will suck large metal things across the room, a length of copper pipe to be used in a magic trick (Dubno sometimes helps his friend, the magician Michael Chaut, build devices for shows), and an Antikythera mechanism—an ancient Greek device sometimes called humanity's first computer. Dubno fashioned one of the only accurate working models in existence out of Lucite using his laser cutter.

Dubno, now 52, is a college dropout and autodidact software programmer who rose to become the chief technology officer of Goldman Sachs. Depending on whom you ask, he is slightly more or less intense about various forms of gadgetry than is his brother, Dan, 55, a former CBS News producer. In 1998 Dan came across a speech given by Al Gore in which the then vice president mused about a satellite-based photo- and data-collection system that could render every inch of the earth into a vast digital online map. Dan, who had used technology to enhance the news since arriving at CBS in 1989, was intrigued. "What I wanted was the ability to zoom in from outer space to any area in the world," Dan recalls. "Say an earthquake happened, or whatever terrible thing it was—I wanted all this metadata and real data so we could illustrate what was going on before our cameras could even get to a place."

He discovered an obscure startup called Keyhole, which was developing software that could create a Web-based map of Earth composed of high-resolution satellite images. He also found satellite-imagery companies actually taking such photographs. He merged the two technologies and used the result on the *CBS Evening News* in 2003 when the United States invaded Iraq, showing Saddam Hussein's strongholds and targets of bombing raids well before the network's competitors had such capabilities. As the first person to bring data-visualization technologies like 3D graphics, touchscreens, and high-resolution satellite imagery to television, he transformed the news. He later introduced Google cofounders Sergey Brin and Larry Page to Keyhole's technology. Not long after that the company bought it and turned it into Google Earth.

The Dubnos have fashioned and hacked and fabricated and tinkered with many remarkable things, and have imagined many more. But the most amazing thing they've ever built is something you cannot touch at all.

GREAT MOMENTS AT GADGETOFF



From top:
Robotocist
Helen Greiner;
a Gadgetoff
guest in a
virtual-reality
sphere; artist
and fabricator
Neal Ormond
makes bananas
flambé with a
flamethrower.

THE WHOLE THING STARTED more than a decade ago, when Mike introduced his brother to Greg Harper, a technology consultant then doing work for Goldman Sachs. Both men were serious gadget heads, and competitive about it. When they first met in Mike's office at Goldman, each strove to outdo the other by pulling yet newer or still more exotic gizmos from his pocket or briefcase, like the knife, gun, cannon, missile, nuke sequence in a *Tom and Jerry* cartoon. You might think Dan would have had the advantage, being a network-news producer with a big-time journalist's access to technology companies and government labs. He was known at CBS as such a keen technologist that he wound up on camera as Digital Dan, reviewing the newest gadgets on two of the network's programs, including *The Early Show*—a role he leveraged opulently for access to the inventors and

designers responsible for the technology he discussed.

But Harper, it turns out, was a worthy adversary—"a gadget man's gadget man," according to Dan, a kind of amateur historian of consumer electronics and himself an inventor. Harper holds 21 patents and played a role in developing streaming video and the software that became Windows Media Player. His New York City duplex apartment is stuffed with TRS-80s and Altair 8800s and Revox reel-to-reel tape recorders and Gordon Gekko-era Motorola DynaTACs and first-generation Walkmen and PalmPilots—all the once-hot technological artifacts that Harper can't bring himself to toss. In a barn outside the city Harper stores enough archaic technology to fill three 26-foot moving trucks. "Greg is a psycho," Dan says.

The two had so much fun sparring they started getting together regularly over dinner. Mike served as mediator. Soon other technophiles heard about the gadget one-upsmanship sessions and asked to join in. They called the gathering a Gadgetoff, and at some point it occurred to them that it would be more interesting if they could invite the actual human beings who had invented the things they were showing off. What kinds of ideas might emerge, as if from a breeder reactor, during such confabulations?

The Dubno brothers began to scale up Gadgetoff in December 2004 in the living room of Mike's town house. Among the 27 attendees was Helen Greiner from iRobot with her early bomb-disposal military robot, which wreaked mild havoc on the Dubno furniture. A Silicon Valley mogul arrived with three rather conspicuous companions—young, slim, fashionable women, short of skirt, high of heel, and as out of place in that milieu as an actuary at Cannes. They chatted aloofly until someone commandeered the robot's remote control and drove the machine—a menacing armored device that appeared capable of opening fire—toward the ladies at a rapid pace. They shrieked as it cornered them. "It wasn't really designed for the insides of beautiful, near-Central Park houses," Greiner says today.

The following year the event ballooned to 90 people, who mingled over shrimp cocktail and platters of finger food mostly purchased at Costco. Two world-class hackers chatted amiably with Mark Seiden, a cybersecurity consultant for multinational corporations—essentially a hacker hunter. On the cellphone of MIT professor Sandy Pentland was an app to which people submitted themselves like a polygraph test—"a real-time speech feature analysis application," according to a description by its creators at the MIT Media Lab—which was designed, Dan Dubno recalls, "to determine if someone is boring." Guests sporadically went out into the cold to race one another toward Central Park on prototype Segways that inventor Dean Kamen had brought.

IF THERE WAS A MOTIVATION BEHIND GADGETOFF, IT WAS AN INQUISITIVENESS SO PURE IT WAS ALMOST NIHILISTIC. THEY SIMPLY WANTED TO FIND OUT WHAT THE BEST MINDS WERE UP TO.

An object the size of a small automobile that shouldn't have fit through the door loomed in the dining room. It was a two-man submarine built to photograph surfers in Hawaii. Among those also displaying innovations were gastromolecular chef Homaro Cantu with his experiments in edible printing and MacArthur genius



Erik Demaine with his computational origami. There was no common theme among all these items save for one: Like most things presented at Gadgetoff, they all offered a glimpse of the future.

Dan at the computer that operates the milling machine in his brother's lavish workshop.

WORD OF THE EVENT—part show-and-tell, part screwball colloquium—spread quickly through the overlapping Venn diagram worlds of technology, science, and DIY maker culture. The Dubnos had relied on the same kind of large-scale nerd humor that motivates Caltech pranks, but for the future they imagined something more ambitious: a daylong jamboree of human ingenuity that would include the world's most stimulating inventors, designers, programmers, hackers, craftsmen, machine builders, and masterminds.

Attendance would be by invitation only—not that

that was limiting in any way. The Dubno brothers aren't exactly name-droppers. Or, rather, they do name-drop, but only because it would be difficult for them to recount their exploits without mentioning their many coconspirators—this or that renowned scientist or inventor or Silicon Valley bold-faced name who winds up having an important role in the story. Mike's Anti-kythera project, for example, originated with Danny Hillis, a computer scientist, inventor, and former Disney Imagineer who is now designing and building something called the 10,000-Year Clock under the auspices of a brainy but vaguely defined think-tankish organization called The Long Now Foundation. The brothers have come to sit at the hub of a network of connections that spans so many people in so many fields and subfields of science and technology and engineering that you could create a game called Six Degrees of Dubno. "I think there are two degrees of Dubno," says Kamen. "One is Mike and the other is Dan."

Partly this is the result of Gadgetoff's popularity. With each successive event the brothers found it easier to amass a list of invitees that attracted still more innovative minds. "That was one of the best parts about Gadgetoff—the quality of the people who were there," says Astro Teller, the artificial-intelligence scientist and head of Google's secretive advanced-research arm, Google X (and grandson of theoretical physicist Edward Teller, who is referred to as the father of the hydrogen bomb). "They aggregated around themselves some of the most creative people I have met in my life," says Yossi Vardi, the Israeli venture capitalist best known for backing the startup that popularized instant messaging. As Dan puts it, "We have a history of collecting innovators."

They wound up hosting former Microsoft CTO Nathan Myhrvold; Red Whittaker, the Carnegie Mellon roboticist; Gary Lauder, a venture capitalist and scion of the Estée Lauder fortune; Martin Eberhard, cofounder of Tesla Motors; and MakerBot cofounder Bre Pettis, who brought his first-generation 3D printers. Jeff Bezos came to observe and politely dodge questions about Amazon's next move. If there was a motivation behind Gadgetoff, it was an inquisitiveness so pure it was almost nihilistic. There was no point beyond curiosity. No talk of progress or of fixing the planet. They simply desired to find out what the best minds were up to. "If you want to know what the future looks like," Dan says, "befriend the people inventing it."

The pursuit of knowledge for the sake of invention seemed natural enough. The Dubnos grew up first in Brooklyn, then the Bronx (both attended the famed, elite school Bronx Science), with a father who worked for nearly 50 years as a patent attorney. Herbert Dubno also knew electrical wiring and carpentry and car engines. For fun, he plumbed. With one arm. He lost the other in an accident on a New Jersey farm as a young man. He went back to school in his 50s just because he was curious. "Somehow he got New York Medical College to let him in," Dan says. (He completed the course work but did not receive a medical degree.) "He taught us you could learn anything about anything, and you shouldn't be intimidated by any field," Dan says. "His ethos was not only can you do it yourself, you must."



**GREAT MOMENTS
AT GADGETOFF**

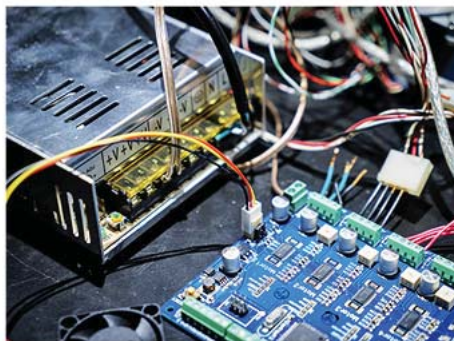


From top: The control box for a newly unveiled robot; oversize Tesla coil towers provide fireworks; a test drive of the Eye-Writer, which allows users to draw using only their eyes.

In the late 1970s, when he was 15, Mike became so engrossed in computer programming that he found a summer job at a small Wall Street investment house writing code for custom software that could track clients' trades. His parents, aware of their son's blossoming interests, had bought him a NorthStar Horizon microcomputer, the kind with toggle switches on the front. "My dad equated it to a piano," he says. "If your kid is gifted musically—which I was not—you'd get him a piano. This was my piano."

When it came time for college, Mike lasted less than an academic year at Rensselaer Polytechnic Institute, even though the university paid him to tutor other students in computer programming. He says, "I didn't understand that school was supposed to be for my benefit." He entered the workforce, taking temporary code-writing gigs at Merrill Lynch and then Chase Manhattan Bank. He also worked at one of New York's first retail computer stores, called Digibyte, a major Atari distributor. Once, several Atari people came to give a demonstration and wound up asking Mike to help them design a new game. Later someone from Atari called and said there had been a mix-up; the company already had 20 people in-house working on it. "I said, well, there's a problem, which is that I'm done. And the guy says, that's tough luck. And I said, either you pay me or I sell it, but it's not tough luck." Mike found a manufacturer and sold the disks himself to retail outlets. He called his game Megalegs. Atari called its Centipede. They hit the market around the same time, and reviews in some gaming journals called Megalegs superior. Atari sued Michael Dubno, age 20, and although he won a small settlement, the encounter ended his nascent video-game enterprise.

Several years later he was hired as an independent contractor by one of Goldman Sachs's new partners:



Clockwise from above left: Mike welds a piece of steel; the power supply and motor control board he built to operate an invention called a Sand Table, which involves making art with a magnetic ball; an assortment of the tools that enable his passions.

the economist and mathematician Fischer Black, he of the Black-Scholes equation, the algorithm used to price options that is now a cornerstone of modern finance. ("It's basically a heat-diffusion equation," Mike explains.) Black became Mike's mentor. In 1986 the young programmer wrote the code for one of Wall Street's first automated-trading programs. A year later, after the Black Monday crash, some blamed computerized systems like Goldman Sachs's. In 1991 Mike wrote the risk-management program, still in use today, to which various experts have attributed the firm's escapes from the various financial crises of the past 20 years. It wouldn't be a stretch to say that he programmed the immune system of the vampire squid. By the time the company went public in the 1990s, he'd made partner. In 2005, with Gadgetoff blossoming, he retired.

AFTER THE 2005 GADGETOFF the founders decided that their gathering had outgrown Mike Dubno's brownstone. The following year they moved it to Governors Island, in New York Harbor, the first time the decommissioned Coast Guard base was used for such an ambitious event. It was there that Gadgetoff achieved its mature state. The island's sprawling indoor and outdoor spaces meant plenty of room for larger machines and more outrageous exhibitions, many with dubious or zero utility, including the latest work by Didi Vardi, brother of Yossi and perhaps the world's greatest designer of Rube Goldberg machines, who created a kinetic sculpture using lasers, golf balls, wire coils, and mirrors.

There were also exhibits of probable far-reaching utility. At the 2007 Gadgetoff, held on the grounds of the Liberty Science Center in Jersey City, New Jersey, attendees got a look at the first self-driving cars

designed by Red Whittaker and his protégé Sebastian Thrun, who led the autonomous-vehicle initiative at Google X. Rodney Brooks, the MIT professor emeritus who served as a subject of, and who gave the title to, Errol Morris's documentary *Fast, Cheap & Out of Control*, was a return attendee. At Gadgetoff there were fast things and cheap things and out-of-control things. Future installments would include a catapult-slingshot seige engine, known as a trebuchet, which launched all manner of items hundreds of yards across a field, and a jet-powered motorcycle built by Chris Hackett, the dreadlocked lord of an artist-maker combine called the Madagascar Institute. "It's surprisingly easy to make a jet engine," Hackett says. "An inefficient one, that is." At another installment, Hackett brought a jet-powered swing ride whose engine was so loud (and thus inefficient) that nearby residents complained to the police. This was the event's spirit: the somewhat haphazard juxtaposition of the beneficial and the absurd.

"It sounds extreme, but Dan and Mike's view is people don't blow things up enough anymore," Teller says. "There's something about that NASA-inspired juvenile hacking that used to go on. With Gadgetoff, they got you reexcited about being silly with technology. It drives a lot of learning. It drives creativity."

Gadgetoff reached its zenith in 2009. Five hundred people flocked to a former home for retired sailors called Snug Harbor, on Staten Island. It was by far the largest Gadgetoff. Costs ran well into the six figures. The event was never for profit, and the Gadgetoff brain trust often waived entrance fees, which were only meant to cover costs. "If you want to ask real inventors to come, and they're hauling a Doppler machine to New York City all the way from Florida, you can't charge them an entrance fee," says Greg Harper.

Ever since its launch in Mike's living room, Gadgetoff had included an array of presentations. If you couldn't bring your gadget, or if you had no gadget but an area of inquiry or body of work, you could give a talk. You had 3 minutes. "Except for the guys from DARPA," Dan says. "We gave them 7." That's DARPA, as in Defense Advanced Research Projects Agency, as in the R&D lab of the Pentagon.

For all its hijinks and invention-for-the-sake-of-invention zeitgeist, Gadgetoff always included certain military-industrial-complex types and others whose appearance hinged on the invite-only nature of the event. (Media coverage was mostly banned.) Pablos Holman, a well-known hacker who once demonstrated at Gadgetoff a Yagi antenna he'd rigged so he could decrypt a Wi-Fi network and take control of someone's computer from 2 miles away, says, "I've met billionaires at Gadgetoff. Reclusive ones. The truth is, Gadgetoff is good for the world. It seems like this big party, but we've helped each other. It's like a community of people that wouldn't have known each other otherwise."

Dan Dubno has mentioned, in somewhat vague terms, his dealings with In-Q-Tel, which is essentially a venture-capital shop financed by the CIA. An outsider may, given recent developments involving, for example, Edward Snowden, have questions about this. But Dan skirts this line of inquiry, noting that identifying a U.S. intelligence agent is a crime.

Continued on page 128

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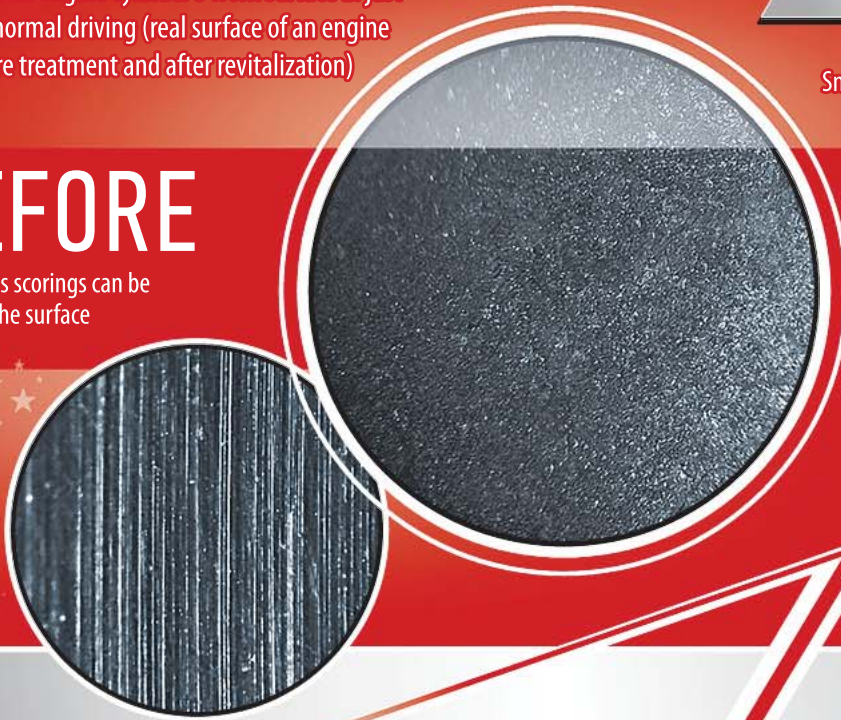
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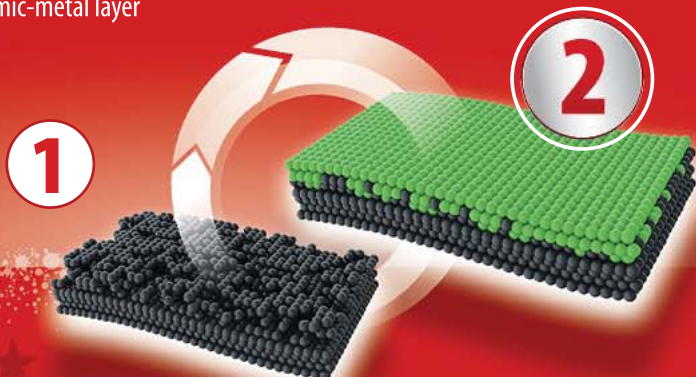
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Gifts From the Workshop

Impress your friends. Inspire the kids. Christmas morning belongs to the guy with the best tools. BY ROY BERENDSOHN

Our homemade diamond-plate toolbox is hardy and easy to clean. Plus, it will add a dash of *Mad Max* to any car project.

Psychologists call it a Duchenne smile, but you'll know it as the reaction you're hoping for when you've handed over a foolproof gift: Your recipient's eyes crinkle as your thoughtfulness unleashes a torrent of helpless joy across her face. A perfectly executed store-bought gift can elicit this sort of reaction, of course, but a smile earned by something you built yourself bestows a bigger rush. Over the next few pages, you'll find our original plans for a pair of sure-fire presents: a diamond-plate toolbox and a red wagon. They're the kinds of gifts that will make your recipient admire the lines, the workmanship, and your care and fortitude. In return, you'll get a smile worthy of all your hard work.



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PROJECT

FOR ADULTS

A Hot Rodder's Toolbox

M My buddy Bob Lucchesi inspired this metal box. He used one just like it in his racing days to tune up his dragster. He would remove the engine's carburetor and eight spark plugs and rack them neatly in the box to keep everything orderly during tuneups. With a backstory like that, this box will be treasured in any gearhead's garage.

STEP 1

Make the Tray

Make the five box panels using a jigsaw and a Bosch T227D aluminum saw blade. Crosscut the four supports from a length of L-shaped aluminum. You're going to attach the L-shaped supports around the bottom panel's perimeter to hold up the sides and ends. Clamp the bottom supports to the ends of the bottom panel, and bore $\frac{1}{8}$ -inch bolt holes through the supports where they meet the panel. Use a 118-degree twist drill bit to bore these holes. Bolt the end supports to the bottom panel. Do the same for the side supports.

Next, clamp the end panels in place, and bore $\frac{1}{8}$ -inch bolt holes through the supports and the panel. Bolt the end panels in place. Complete the body by repeating this procedure with the sides.

Crosscut the inner and outer corner supports, and bore $\frac{1}{8}$ -inch pilot holes through them and the corners of your box so that they make a sandwich: inner support, box corner, then outer support. Mount the supports by driving sheet-metal screws through all three pieces.

STEP 2

Add a Handle

Crosscut the handle supports. Use a compass to mark the top curve; cut it with a jigsaw. Next, bore a large hole into each support for the handle to slide through. Use a bimetal hole saw or a step drill, a conical bit with notches cut into it (each notch makes a different-size hole). Crosscut the handle using a plumber's tubing cutter, which is

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available at most hardware stores and is a good tool to have around. Install the supports by bolting them to the ends of the box, then slide the handle through its holes. Next, drill two $\frac{7}{64}$ -inch holes through the handle, one just behind each support. Cut threads in the handle with a 6-32 tap. Fix the handle's position in the supports by threading machine screws through the holes. The box can now be loaded with a carburetor, plugs, or something less greasy. Candy canes, maybe.

TIP

Aluminum may be softer than steel, but it can be tough to work with because its particles build up on saw blades and drill bits. To prevent this, use a cutting lubricant designed for nonferrous metal, such as AlumTap.

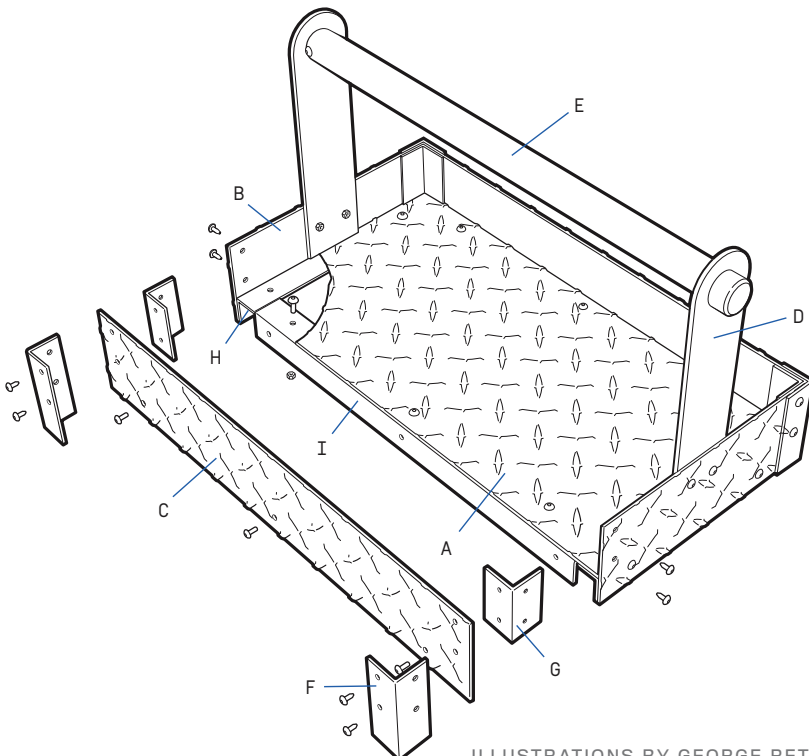
Materials

PART	QTY.	DESCRIPTION	MATERIAL	DIMENSIONS
A	1	Bottom panel	Diamond-plate aluminum	$\frac{1}{16}$ " x 8" x 16"
B	2	End panel	Diamond-plate aluminum	$\frac{1}{16}$ " x 3" x 8"
C	2	Side panel	Diamond-plate aluminum	$\frac{1}{16}$ " x 3" x $16\frac{1}{8}$ "
D	2	Handle support	Aluminum flat stock	$\frac{1}{8}$ " x 2" x $8\frac{1}{2}$ "
E	1	Handle	Steel-tube closet rod	1" x $17\frac{1}{2}$ "
F	4	Corner support (outer)	Aluminum angle	$\frac{1}{8}$ " x 1" x 3"
G	4	Corner support (inner)	Aluminum angle	$\frac{1}{8}$ " x 1" x $1\frac{7}{8}$ "
H	2	Bottom support (end)	Aluminum angle	$\frac{1}{8}$ " x 1" x 8"
I	2	Bottom support (side)	Aluminum angle	$\frac{1}{8}$ " x 1" x 14"

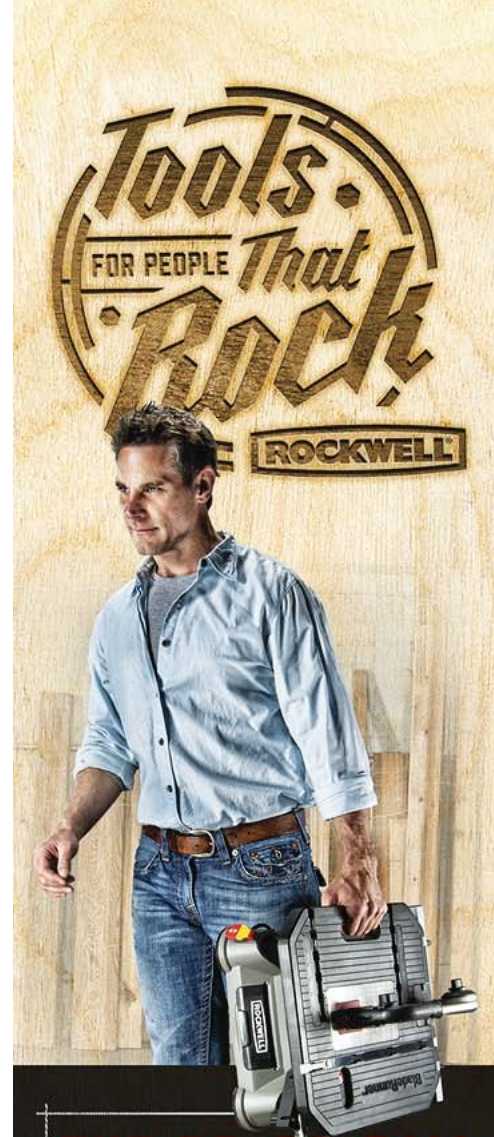
Fasteners

1 22-piece pkg $\frac{3}{8}$ -inch No. 6 pan-head sheet-metal screws

1 100-piece pkg No. 6-32 x $\frac{1}{2}$ -inch round-head machine screws with nuts



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PROJECT



FOR THE KIDS

A Wooden Wagon

A toy wagon is the quintessential holiday gift, even in an age as digital as this one. It doesn't need batteries, and it's nearly impossible to wear out. It never goes out of style. Your kids will be hauling the dog around in it within a week. And if you build your wagon well, someday their kids might use it for the same purpose.

STEP 1

Make the Body

Make the wagon-box parts and apply latex primer. Attach the side panels to the front and back panels with wood glue and 6d finish nails. Paint everything red, though. Bore a $\frac{1}{4}$ -inch hole for the steering bolt through the bottom panel.

Make the side rails, back rail, and bat-

ten on the back and side rails. Cut the curves with a jigsaw and a 20-tpi (teeth per inch) blade. Prime and paint these parts. Once they're dry, attach each batten to the wagon's side and ends with a pair of 1-inch No. 6 wood screws and finish washers.

STEP 2

Add Running Gear

A good farm wagon rolls on sturdy running gear, and so does a good toy wagon. Crosscut the plywood and solid wood blocks for the wheel trucks, and then glue and screw them together. Apply a coat of polyurethane to the outside of both. Glue the two rear wheel trucks to the bottom panel, and wait for the glue to dry before driving a pair of $\frac{3}{4}$ -inch screws with finish washers through the bottom panel and into the wood blocks.

Crosscut the wood for the steering yoke; cut the curve on its front edge using a jigsaw. Use a 20-tpi blade rated for cutting curves. Sand the front edge smooth,

WAGON DESIGN AND CONSTRUCTION BY JOSEPH TRUINI

and drill the hole for the eye screw that will attach the handle to the yoke. Carefully center and drill the bolt hole in the yoke. Now glue and screw the front wheel trucks to the yoke in the same way that you attached the rear trucks to the wagon. That completes the yoke assembly. Apply a coat of polyurethane to the top of the yoke. When this has dried, bolt the yoke to the wagon body.

STEP 3

Attach the Handle and Wheels

To make the handle, crosscut the dowels, then place the short dowel in a vise and bore a hole in its center using a spade bit. Apply polyurethane to both dowels, then glue and screw the shorter dowel to the longer one. Bore the pilot hole for an eye screw into the opposite end of the long dowel. To connect the handle to the wagon, connect a large eye screw to a small eye screw. First, twist the smaller screw into the handle and the larger screw into the steering yoke; then slip the large screw through the gap in the smaller one.

Cut the axle bolts to length, and mount the wheels, washers, and bolts to each truck. Gently tighten the cap nuts. There you have it: a classic holiday present for the kids. The only thing that would make them happier is if you put this under the tree with a puppy in it. We can't teach you how to make one of those.

Materials

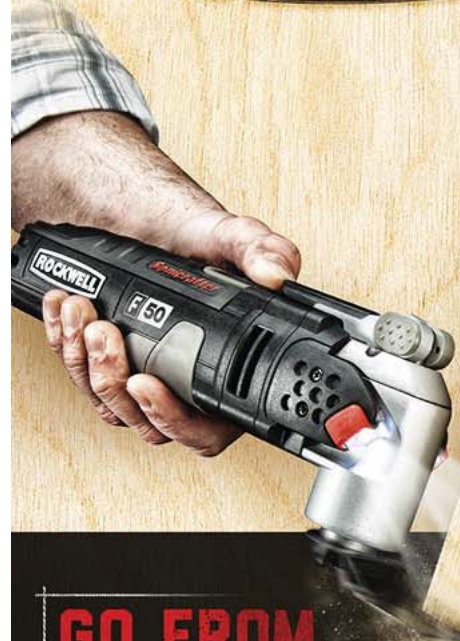
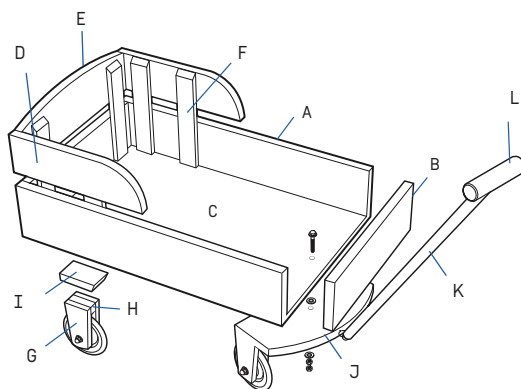
PART	QTY.	DESCRIPTION	DIMENSIONS
A	2	Side	$\frac{3}{4}$ " x $4\frac{1}{2}$ " x 24"
B	2	End	$\frac{3}{4}$ " x $4\frac{1}{2}$ " x $14\frac{1}{2}$ "
C	1	Plywood bottom	$\frac{1}{2}$ " x 16" x 24"
D	2	Side rail	$\frac{3}{4}$ " x $3\frac{1}{2}$ " x 12"
E	1	Back rail	$\frac{3}{4}$ " x $4\frac{1}{2}$ " x $14\frac{1}{2}$ "
F	6	Batten	$\frac{1}{2}$ " x $1\frac{5}{8}$ " x 9 $\frac{1}{4}$ "
G	8	Wheel truck	$\frac{1}{2}$ " x $2\frac{3}{4}$ " x $4\frac{1}{2}$ "
H	4	Truck separator block	$\frac{3}{4}$ " x $\frac{3}{4}$ " x $2\frac{3}{4}$ "
I	2	Wheel mounting block	$\frac{3}{4}$ " x $1\frac{3}{4}$ " x $3\frac{3}{4}$ "
J	1	Steering yoke	$\frac{3}{4}$ " x 6" x 12"
K	1	Dowel (handle shaft)	$\frac{3}{4}$ " diameter x 24"
L	1	Dowel (handle grip)	$1\frac{1}{4}$ " diameter x 5"

Fasteners/Hardware

QTY.	DESCRIPTION
4	$\frac{3}{8}$ -inch-diameter x $2\frac{1}{2}$ -inch hex-head-bolt axle (Note: Cut off excess $\frac{1}{4}$ inch; finished bolt is $2\frac{1}{4}$ inches.)
8	$\frac{3}{4}$ -inch-diameter washers
4	$\frac{3}{8}$ -inch cap nuts
1	100-piece pkg $\frac{3}{4}$ -inch No. 6 Phillips-head wood screws
1	100-piece pkg 1-inch No. 6 Phillips-head wood screws
1	1-pound pkg 2-inch 6d bright finish nails
4	$\frac{1}{2}$ -inch x $4\frac{1}{2}$ -inch-diameter wheels with $\frac{5}{8}$ -inch hub (Note: item No. 71039 at hardwareistributors.com .)
1	$\frac{1}{4}$ -20 x 2-inch carriage bolt
2	$\frac{1}{4}$ -20 hex nuts
1	1-inch-diameter screw eye
1	$\frac{5}{8}$ -inch-diameter screw eye
16	Finish washers

Adhesive/Finish

1 pint polyurethane, 1 quart acrylic latex primer, 1 quart semigloss dark red acrylic latex, wood filler, wood glue



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Gadget Brothers

CONTINUED FROM PAGE 119

"There were people who worked for various intelligence agencies who presented" is all he'll say.

Various intelligence agencies? The CIA too?

"There were guys who worked for various intelligence agencies—consultants for various intelligence agencies, among other things—who presented, at various points."

Presented secret government technologies?

"No. But . . . I've attended things where people who have represented other governments have showed me stuff that is unbelievable."

THEN, AFTER FOUR large-scale Gadgetoffs, the show abruptly ended. Mike came out of retirement in 2010 to take a job as head of global markets and research technology at Bank of America, and the workload meant he wouldn't have much time for Gadgetoff. Neither Dan nor Greg Harper wanted to do it without him. The brothers

are close in this way. They tend to complete each other's sentences or, when not doing that, point out how the other is wrong on some technical point. But during Mike's hiatus, Dan, who retired from CBS in 2008, has kept the Gadgetoff spirit warm, he says, by producing similar events for Google.

Still, half a decade has now passed. Moore's law states that the processing power for computers will double about every two years, advancing various capabilities along with it. And with so many new lines of technology having bloomed in the interim, an intense hankering has taken hold of Gadgetoff's founders. Recently Mike's workload has diminished. The time for another Gadgetoff may be near. "Everyone is begging us to do it," Dan says.

Asked if he would travel from Tel Aviv for another Gadgetoff, Yossi Vardi says, "If needed, I will be the second person from this region to walk on water."

The Dubnos and Harper become vis-

ibly excited when discussing a Gadgetoff relaunch. (Harper actually hops up and down in his seat.) They say 2015 is likely. They're scouting locations in and around New York City's waterways. "I'd be really interested to see, if they restarted it, what they were trying to do that was new," Astro Teller says. "The world has updated in some interesting ways in the last few years."

The founders want to include ever-more-relevant fields of inquiry: microrobotics, drones, big-data predictive models, cyberwarfare, alternative energy, climate-change antidotes. They'll rely on their network to point them toward the truly innovative and the purely bizarre. "What's great," Dan says, "is that the people who came to previous Gadgetoffs curate the event as much as we do."

If anything is to be changed, it will simply be a matter of more. "Crazier, faster, more stuff, more inventors," Dan says, sounding very much like an inventor himself, preparing the world for his latest, biggest, and most spectacular creation. ■



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Reported by J. Page

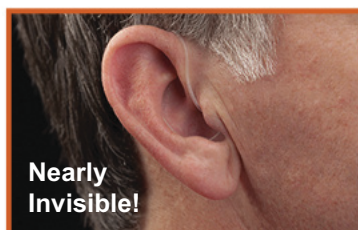
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Of course, hearing is believing and we invite you to try it for yourself with our RISK-FREE 45-day home trial. If you are not completely satisfied, simply return it within that time period for a full refund of your purchase price.

Can a hearing aid delay or prevent dementia?

A study by Johns Hopkins and National Institute on Aging researchers suggests older individuals with hearing loss are significantly more likely to develop dementia over time than those who retain their hearing. They suggest that an intervention—such as a hearing aid—could delay or prevent dementia by improving hearing!

“Satisfied Buyers Agree AIR Is Best Digital Value!”

“I am hearing things I didn't know I was missing. Really amazing. I'm wearing them all the time” —Linda Irving, Indiana

“Almost work too well. I am a teacher and hearing much better now” —Lillian Barden, California

“I have used many expensive hearing aids, some over \$5,000. The Airs have greatly improved my enjoyment of life” —Som Y., Michigan

“I would definitely recommend them to my patients with hearing loss” —Amy S., Audiologist, Munster, Indiana



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PROMOTION



Moderation, panel and pitches by: Scott Kurnit (Founder, Chairman and CEO of Keep.com), John Borthwick (CEO and Co-founder, betaworks), Joe Bargmann (Special Projects Director, Popular Mechanics), and Katherine Oliver (Principal Partner, Bloomberg Associates), Mike Rothman (Co-founder of Fatherly), Anne Trubek (Editor-in-Chief of BELT Magazine), and Andrew Thomas Reid (Creative Director, BKLYN1834).

Popular Mechanics +  THE PALEY CENTER FOR MEDIA

THE NEXT BIG THING

We all want to know what the next big thing will be. Social discovery? The return of the long form? An end to gender-based parenting? To get to the bottom of it, Popular Mechanics tapped the people making things happen today: investors and entrepreneurs.

In late September, this outspoken who's who of the media world met up in New York City to cast their votes. As the leader in the cultural media discussion, The Paley Center presented a mash-up of conversations, elevator

pitches, and Q&As as part of its Next Big Thing series, with support (and fine libations) provided by Tito's Handmade Vodka and innovative telescope maker Celestron.

The room intensely debated new funding models (crowd-sourced or investor-based?), raving all the while about new media markets and novel, technology-driven ways to bring people together.

Watch the recorded talk on "The Next Big Thing Series, Media and the Innovation Economy" at paleycenter.org.



CONTEST RULES

NO PURCHASE NECESSARY TO ENTER OR WIN. POPULAR MECHANICS READERS CHALLENGE CONTEST. Sponsored by Hearst Communications, Inc. Beginning November 11, 2014 at 12:01 AM (ET) through January 13, 2015 at 11:59 PM (ET) (the "Entry Period") submit your entry online or via mail. All entrants must construct something using a single 8x4-foot sheet of plywood pursuant to the Project Guidelines in the complete official rules. Two ways to submit your entry: (i) Online: Send an email to PMWorkshopChallenge@hearst.com with two (2) photos and one (1) drawing of your project, along with instructions on how to build it (jpeg or PDF files preferred); or (ii) Mail: Send two (2) photos and one (1) drawing of your project, along with instructions on how to build it, with your contact information to: Popular Mechanics Workshop Challenge, 300 W 57th St., New York, NY 10019. Your project must be constructed out of a single 8x4-foot sheet of plywood, with the use of any fasteners and hardware of your choosing, but no additional lumber, as described in the Project Guidelines. One (1) Winner will receive a DeWalt DWMT73801 108-piece Mechanics Socket Set (ARV: \$99.99). Important Notice: You may be charged for visiting the mobile website in accordance with the terms of your service agreement with your carrier. Must have reached the age of majority and be a legal resident of the 50 United States, the District of Columbia or Canada (excluding Quebec). Void in Puerto Rico and where prohibited by law. Contest is subject to complete official rules and Project Guidelines available at popularmechanics.com/readerschallenge.

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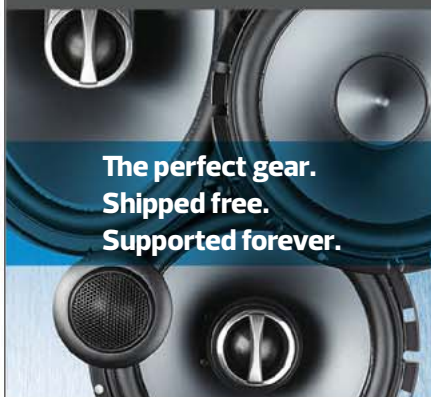
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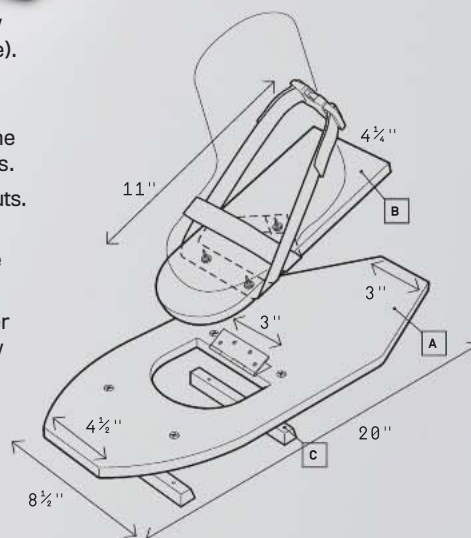
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	2	Utility hinge	3"
	1 qt	Spar polyurethane	

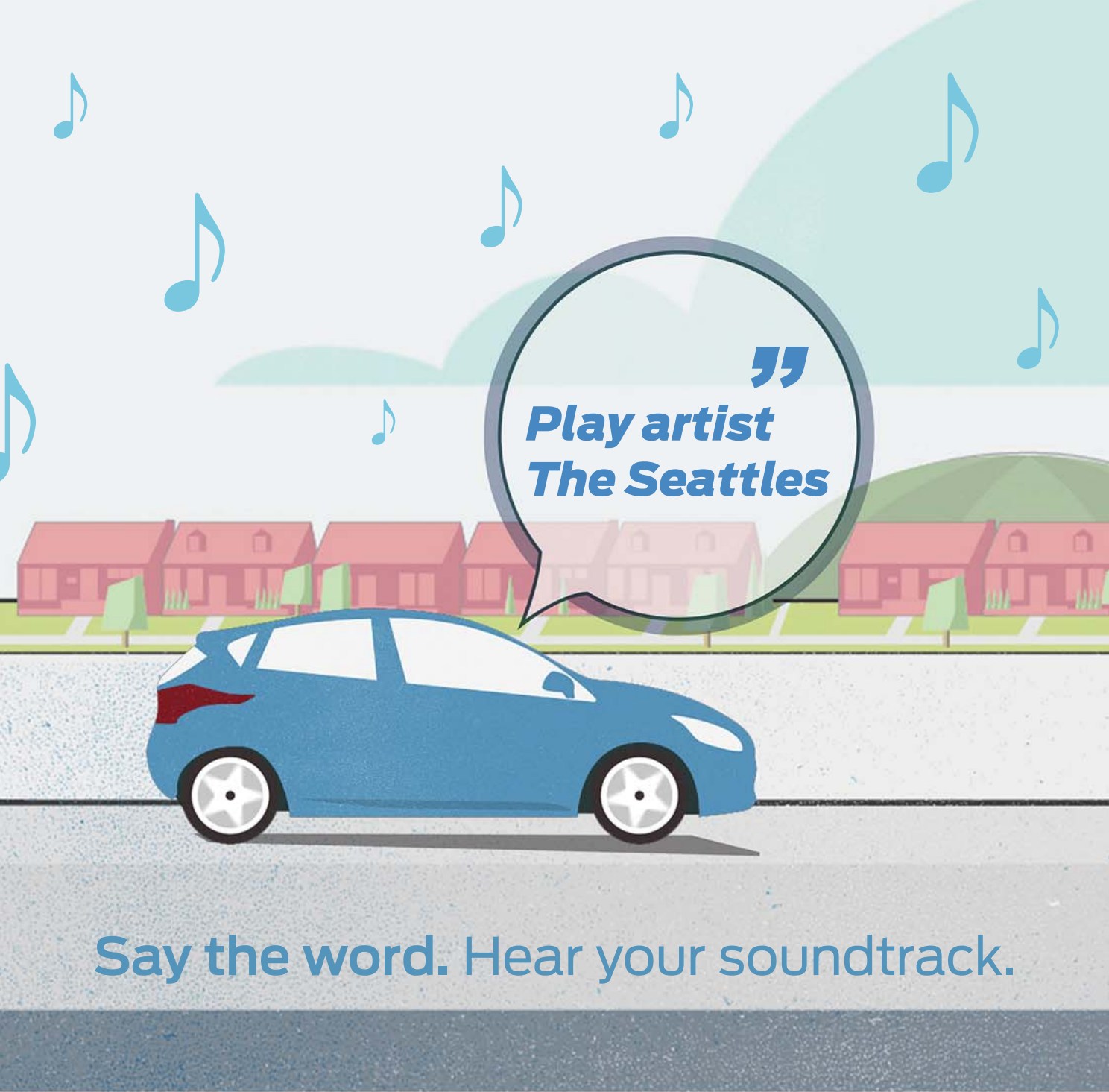


INSTRUCTIONS

1. Rip and crosscut the two rectangles [A] from a sheet of plywood using a jigsaw (10-tpi blade) or circular saw (a 140-tooth plywood or fine-finish 60-tooth blade).
2. Mark and cut the sloped edges. To make the curved cutout, use a $\frac{3}{4}$ -inch-diameter spade bit and punch a hole at the beginning and the end of the curve (like the two bases of a rainbow). Start a jigsaw in one hole and work around the curve to the other hole. Finish by making the straight cut between the two holes.
3. Cut the pivoting footpads [B] to about 11 inches long, slightly narrower than the cutouts.
4. After screwing the cleats [C] to the bottom of each shoe, screw each hinge to the shoe, through to the rear cleat below, then pivot the footpad and screw the hinge into its bottom.
5. To make the bindings, place a boot on the footpad and loop an elastic strap over the laces. Cut to length and affix to the underside of the platform using a screw and trim washer to spread out the force of the screw head. Use a standard synthetic strap with a buckle for the heel binding. Loop it around the heel and under the platform, cut to length, and affix near the front of the platform with two screws and washers.
6. Apply two or three coats of spar polyurethane.

ASSEMBLY





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